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Review of Power System Optimization using PSO

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Abstract

Economic Load Dispatch (ELD) determines the optimum amount of electric power to be generated by a generation plant at the lowest possible cost so as to meet the load requirements and the load variations at the same time meeting the transmission and distribution constraints. ELD is needed to distribute the load amongst accessible generating units paralleled with the system in such a way thus on minimize the entire generation price of the thermal power plant. Optimization involves obtaining feasible solutions to the problem. Several conventional optimization methods like linear method, nonlinear method, quadratic programming, integer and geometric programming had been developed but each method has its own drawback. Recently, improved techniques were introduced to solve these nonlinear problems. The particle Swarm Optimization (PSO) technique is such a non-conventional evolutionary technique based on the population based algorithm. PSO has faster convergence as compared to other optimization techniques and has also capable optimization ability under various problems. We discuss the method and advantages of PSO while implementing on the ELD problems.

Key-words: Economic load dispatch, particle swarm optimization (PSO)

Introduction

The Economic Operation of Power System

The efficient optimal economic operation and planning of electric power generating system has always occupied an important position in the electric power industry. With large interconnection of the electric networks, energy crisis in the world, continuous rise in fossil fuel and tariff structure necessitate the optimal operation of power generating units. A small saving in the operation of generating system results a significant reduction in operating cost of the power plant. The main objective of the economic load dispatch of generating systems is to achieve minimum operating cost of thermal power plant.

This problem has taken a subtle twist in modern generating system, as consumers have become concerned with environmental matters, so that economic dispatch now includes the dispatch of systems to minimize environmental emission as well as achieve minimum cost. In addition, there is a need to expand the limited economic optimization problem to incorporate constraints on system operation in order to ensure the security of the system, for preventing collapse of the system due to unforeseen conditions. However closely associated problem with this economic load dispatch, is the commitment of any unit out of a total array of units to serve the expected load demands in an optimal way. For the purpose of optimum economic operation of this large scale interconnected system, modern optimization techniques are being applied with the expectation of considerable cost savings

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Economic Load Dispatch

Economic load dispatch is the method of confirm the low fuel cost, most effective and reliable operation of a system. The first objective of economic dispatch is to reduce the overall cost of generation of thermal power house whereas satisfying the constraints another word it is also additionally outline because it is a method of allocating masses to plants for minimum price whereas meeting the constraints. It is developed as an optimization problem for minimizing the overall fuel price of all dedicated plants whereas meeting the demand [4].

The Economic Load Dispatch is an important part of modern electrical power system such that Unit commitment, Load forecasting, Available Transfer Capability (ATC) calculation, Security Analysis (SA), scheduling of fuel purchase etc. A bibliographical survey on ELD methods reveals that various numerical optimization techniques have been employed to obtain the solution of the ELD problem. ELD problem solved traditionally using mathematical programming based on optimization techniques such as Particle Swarm Optimization (PSO) with valve point effect and its variants i.e. Self-Organizing Hierarchical Particle Swarm Optimization [2][3],Hybrid Particle Swarm Optimization Approach [4],Quantum-Inspired Particle Swarm Optimization (PSO) with valve loading [5] and Bacterial Foraging Optimization Based Dynamic with Non-Smooth Cost Function [6]. Economic load dispatch with piecewise linear cost functions is a highly heuristic, approximate and extremely fast form of economic dispatch [2]. As power demand increase and fuel cost booms in recent years, reduction the operation costs of power system becomes an important issue. One of the choices is to operate generators efficiently and economically.

Nevertheless, economic dispatch problems with multiple-unit and piecewise quadratic cost functions will exist many local extreme points [4]. As a result, conventional optimization techniques are no longer the best choice since they may fail to locate the optimal solution and result in considerable errors. Recently, the advances in computation and the search for better solution of complex problems have lead to using stochastic optimization techniques, such as ant colony optimization [4-5], Evolutionary algorithm [6-7], particle swarm optimization [8], differential evolution, and etc., for solving economic dispatch problems.

The ELD drawback can be formulated in many ways. The fundamental economic dispatch drawback can be described mathematically as reduction of the overall fuel price of all committed plants subject to the constraints. The new technology invested with the Engineers increasing the potency of boilers, turbines and generators of thermal power plant thus continuously that every new superimposed to the generating unit plants of a system operates additionally with efficiently than any older unit on the power system[21]. Operational of a system for any load demand condition the contribution from every generating unit inside a plant should be determined in order that the price of the delivered power is minimum.

The economic load dispatch problem gives the solution of two different issues. The primary of those is the unit commitment (pre-dispatch problem) whereby it is needed to pick generating sources optimally to fulfill the expected load and supply a specified margin of operating reserve over a specified amount of time. The second part of economic dispatch is that on line economic dispatch whereas it is needed to distribute load among the out there generating units in such manner on minimize the overall price of offer the load demand needs the system [15]. The target of this work is to seeks the solution of nonlinear on line economic dispatch problem by exploitation change PSO algorithm called improved inertia weight PSO[18].

Optimization Technique

Particle Swarm Optimization

PSO [4, 7, 24] is the new optimization technique developed by Kennedy and Eberhart in 1995[4]. Eberhart, Simpson and Dobbins proposed PSO in 1996. It is basically inspired by the natural aspect such as fish schooling, bird flocking and human social relation. Particles of PSO initialized randomly with a population for random solution of the problem. Each optimal solution of PSO is assigned a random velocity in such a way that the particle moves in the search area. The optimal solution obtained by this method is called particles. These particles flow in the problem search space. Each particle keeps track of its coordinates in the problem search space which are associated with the best solution of the problem it has achieved so far. This value of the solution is called p_{best}. Best values of P_{best} is tracked by the global version of the particle swarm optimizer is the overall best value called $g_{best.}$

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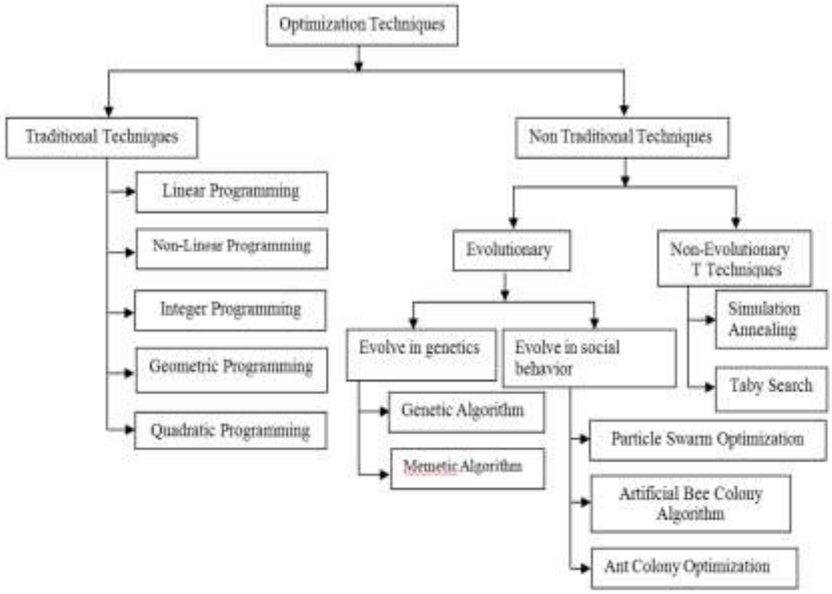

Fig.1Optimization Techniques [31]

The detailed implementation steps of PSO are as follows:
Step1: Initialize swarm randomly
For the d- dimension search space PSO initialize a population of particles with random positions and velocities.
Step2: Calculate fitness function
In the d-variables evaluate the desired optimal fitness function for each particle.
Step3: Compare the particle fitness evaluation with p_{best} value of particles.
If current value of particles is better than p_{best} of the solution, then set ofp_{best}value equal to the current value of particles and assuming the p_{best} location equal to the current location in d-dimensional search space.
Step4: Compare fitness assessment with the populations of overall previous best.
If current value of particles is better than P_{best}, than reset $g_{best}$to the current particles array index and value.
Step5: Update the velocity of the particle according to equation (1)

$$V_i^{(K+1)} = WV_i^K + c_1 Rand_1 \times (Pbest_i - S_i^K) + c_2 Rand_2 \times (gbest - S_i^K) \quad (1)$$

Where,$V_i^{(K+1)}$ is the particle velocity at current iteration (k+1).
$V_i^K$is the particle velocity at (k+1).
r_1, r_2 are random number between [0, 1].
c_1& c_2 are acceleration coefficients
The acceleration coefficients $c_1$and c_2 shown in eq. (1)[4][14] represent the stochastic acceleration terms that pull each particle toward p_{best} and g_{best}positions. The values of c_1 and $c_2$are equal to 2 for obtaining global best solution of the problem. Velocity of the particles V_{max} and V_{min} are set in such a way that the particles explore in the search area and cannot escape from the search area.

Step6: The position of the particle updated as given in eq.(2)

$$S_i^{(K+1)} = S_i^K + V_i^{K+1} \qquad (2)$$

Where, $S_i^{(K+1)}$ is the current particle position at iteration k+1.
S_i^Kisthe current particle position at iteration k.

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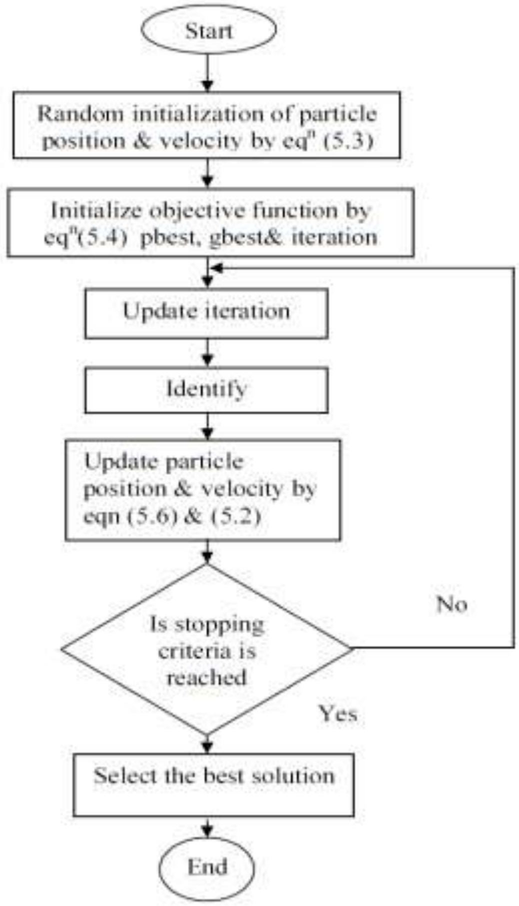

Fig.2 Flow Chart of PSO

Advantages of PSO

PSO is a population based evolutionary optimization technique and can be efficiently applied to the ELD problems due to the following advantages [24] [31]:

1) PSO requires only a fitness function to measure the solution of the problem instead of other complex mathematical operation like gradient inversion.
2) PSO is a population-based method so it is less sensitive to a good initial solution.
3) PSO can forms hybrid system because it easily incorporated with other optimization tools.
4) PSO follows probabilistic transition rules so it has the ability to escape local minima.
5) PSO is easy in programming and it can be modified with use of basic mathematical and logical operations.
6) PSO takes very less computation time and memory space.
7) PSO requires less parameter for tuning.

Conclusion

Economic load dispatch in electric power sector is an important task, as it is required to supply the power at the minimum cost which aids in profit-making. As the efficiency of newly added generating units are more than previous units, hence economic load dispatch has to be efficiently solved for minimizing the cost of generated power. Load dispatch problems are solved for four different test systems i.e. three, six, thirteen & sixteen units generating station. For each test system mentioned above economic load dispatch schedule has been determined by Linearly Decreasing Inertia Weight PSO. The program has been coded in MATLAB version 7.5 and results are obtained, which are typically compared with the results available in literature. In present work, linearly decreasing inertia weight has been successfully applied to determine the generation schedule of all thermal units for the test system considered. Here valve point loading effect of thermal generating units, ramp rate limits, spinning reserves

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and transmission losses are not considered which can be considered in future. Apart from this optimization problem can be formulated as multi-objective problem, considering one more objective function i.e. minimization of green-house gases emission.

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