Improving Voltage Stability in Multi Objective Economic Power Dispatch with Emission Constraint Using New PSO

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Abstract - Economic power dispatch (EPD) is the important optimization technique in electrical power system. Economic load dispatch plays important role to determine the generating fuel cost and efficiency of electrical power system to make system more reliable and better operating condition . In this paper we considered EPD problem for multi objective function voltage stability , emission constraints and fuel cost of generating units are the main objective constraints to solve multi objective EPD . Here we not only solve the EPD problem but also minimize the environmental emission and increasing reliability of the power system. Particle swarm optimization is the most popular optimization techniques used for the EPD problem. PSO is the population based optimization techniques is inspired by sociological behavior of ant . PSO can be used to solve multi-objective with voltage stability constraints EPD problem. This paper used a PSO with constriction factor for voltage stability for solving EPD problem, which enhances the ability of the particles to explore the solution spaces more effectively and increases their convergence . In this work the CPSO algorithm is demonstrated for simple and reliable EPD through its application generator systems with emission constraints.

Keywords- Voltage stability, Minimum fuel cost, Emission constraints, Economic dispatch.

I. INTRODUCTION

Electric power system is interconnected with tie line to achieve the maximum efficieny, optimum production cost ,low transmission loss, reliability and better operating conditions. Tie line is inter connected between generating stations i.e. used in contingency, it is required to distribute the load among the generating units which are actually paralleled with the system, in such a way as to minimize the total operating cost of generating units while satisfying system equality and inequality constraints. For any specified load conditions, EPD determine the power outputs of each plant (and each generating unit within the plant) which will minimize the overall cost of fuel needed to serve the system load [1]. EPD is used in real-time energy management power system control by most programs to allocate the total generation among the available units. EPD focuses upon coordinating the production cost at all power plants operating on the system. EPD achieve the benefits of generating prize and improve operating condition.

Conventional as well as modern methods have been used for solving economic load dispatch problem employing different objective functions. Various conventional methods like lambda iteration method, gradient-based method, Bundle method [2], nonlinear programming [3], mixed integer linear programming [4], dynamic programming [6], linear programming [7], quadratic programming [9], Lagrange relaxation method [8], Newton-based techniques [10], reported in the literature are used to solve such problems.

Conventional methods have many draw back such as nonlinear programming has algorithmic complexity. Linear programming methods are fast and reliable but require linearization of objective function as well as constraints with non-negative variables, disadvantages of genetic algorithms because it takes long time to get output and its complexicity. neural network method is very complex as well as unreliable also some other methods such as evolutionary programming (EP) [11], simulated annealing (SA) [12], Tabu search (TS) [13], pattern search (PS) [14], Genetic algorithm (GA) [15], Differential evolution (DE) [16], Ant colony optimization [17], Neural network [18], particle swarm optimization (PSO) [19], [20], [21], Real coded genetic algorithms[24],SHOPSO [22], WIPSO [28],MOPSO [29]. Although the heuristic methods do not always guarantee discovering globally optimal solutions in finite time, they provide the reasonable and fast solution. EP is rather slow converging to a near optimum for some problems. SA is very time consuming, and cannot be utilized easily to tune the control parameters of the annealing schedule. TS is difficult in defining effective memory structures and strategies which are dependent on problem. GA many times has lack of convergence and reliability caused by their slow speed.

Particle-swarm-optimization (PSO) method is based on different techniques like Evolutionary technique first introduced in [21], and it is inspired by the emergent motion of a ant searching food. In comparison with other GAs such as EAs the PSO gives considerable and superior output with stability so PSO has been extended to electrical power systems, neural network training, image processing and so on.

The main objective of the study of New PSO is development of particals condition their best condition and find its optimum condition.

The proposed method focuses to improve voltage stability on solving the economic power dispatch with multi constraint. The flexibility of the proposed method is convergence for three and six generating system. The results obtained by the proposed optimization and compared with those reported in recent literatures

II. PROBLEM FORMULATION

In this section, we are formulating the optimization problems in electrical power system economic load dispatch with multi objective constraints that have multiple ramp rate objectives. In what follows, the performance of the generating units equality and unequality indices constraints pertaining to the power system problems is described.

Objectives

In economic load dispatch optimization the most important indices can be evaluated environment effect , total power loss and economy.

A. basic economic dispatch formulation to minimize the fuel cost

ED has most of the important problem can be solved in the generating power system for operation . the first step of an ED problem is the minimization of its functions. The total cost that meets the load demand all other constraints associated is selected as the objective function.

The ED formulation to minimize the fuel cost is mathematically formulated in (1) and (2),

$$F_T = \text{Min } f(F_i(P_i)) \quad (1)$$

$$F1(P_i) = \sum_{i=1}^{n} a_i \times P_i^2 + b_i \times P_i + c_i \quad (2)$$

Where, F_T is the objective function.

a_i, b_i and c_i are the coefficients of cost.

B. Minimization of Emission

The emission function can be presented as the sum of all types of emission considered, such as NO2, SOx, thermal

emission etc., with suitable pricing or weighting on each emitted pollutant. In the study, only one type of emission (NO2) is taken into account without loss of generality. The amount of NO2 emission is given as a function of generator output, that is, the sum of exponential and quadratic l function.

The Emission equation of the ith generating unit is usually described as:

$$E_i(P_i) = \sum_{i=1}^{n} d_i \times P_i^2 + e_i \times P_i + f_i \quad (3)$$

Where d_i, e_i and f_i are the emission co-efficient of the i_{th} unit.

So emission constraints can be formulated as (4).

$$P_i^{'}(P_i) = F_i(P_i) + hE_i(P_i) \quad (4)$$

$$h = F_{iMax}/E_{iMax} \quad (5)$$

where,

$$F_{iMax} = a_i P_{iMax}^2 + b_i P_{iMax} + c \quad (6)$$

$$E_{iMax} = d_i P_{iMax}^2 + e_i P_{iMax} + f_i \quad (7)$$

C. ***CONSTRAINTS***

The following constraints are using in this -

1). **Power balance constraints**

The generated power should be equal to load demand

$$\sum_{i=1}^{n} P_i = P_D \quad (8)$$

Where, P_D is the total system demand.

2). **Generator Limits**

To achieve maximum efficiency generator will be maintain is optimum condition because power is generated generating station has its own minimum load so we consider generator maximum and minimum limit it delivers maximum its full load condition .so maximum and minimum limits lies on generating load condition.

$$P_i^{min} \leq \mathrm{P_i} \leq P_i^{max} \tag{9}$$

Where, Pi is the output power of ith generator,

$P_{i,min}$ and $P_{i,max}$ are the minimum and maximum power outputs of generator i respectively.

3).**Voltage Stability Limits**

The voltage stability of electric power system is the big factor to introduce efficiency of the system . so to improve voltage stability diagonal elements and jacobies matrix can be formed of load flow analysis .the index is give as

$$\boldsymbol{I} = \frac{\boldsymbol{dp}}{\boldsymbol{d\delta}} / \sum \text{bij Vj}$$

Where,p is real power injection of i th bus

δ is voltage phase angle of i th bus

Bij is susceptance of ij bus

Thus voltage stability becomes

I > 0.58 for i=1,2…..n bus

III. OVERVIEW OF SOME PSO STRATEGIES

A. STANDARD PARTICLE SWARM OPTIMIZATION (PSO)

Particle swarm optimization was firstly introduced 1995 [21]. It is the new method in computational evalutionary and a population-based optimization tool. PSO is motivated from the behavior of social systems such as birds flocking and fish schooling . It is the powerful optimization technique is used for scatters random particles. These particles collect information from each array constructed by their respective positions i.e, called swarms. The particles are updated their velocity to improve efficiency. Position and velocity are both updated from particles' own experience and the experience of its neighbors.

the simulation of the behavior of social systems such as birds flocking and fish schooling . It is the powerful optimization tool which scatters random particles, i.e., solutions into the problem space. These particles collect information from each array constructed by their respective positions i.e, called swarms. The particles update their positions using the velocity of articles. Position and velocity are both updated in a heuristic manner using guidance from particles' own experience and the experience of its neighbors.

In PSO, each individual is called a particle which is made of two parts, the velocity and position.velocity represents the step size a particle attempt to move in next turn and Position is the objective variable. A particle represents a potential or candidate solution of the problem. The particles are responsible for searching the solutions within the multi dimensional problem space according to two major operations, velocity and position updating rules. Each particle moves toward the optimal point by adding velocity to its position [10-11]. Considering the d_{th} dimension, the updating

The particle updates its velocity and position using (10) and (11)

$$\mathrm{V_i^{(K+1)}} = \mathrm{WV_i^K} + \mathrm{c_1 Rand_1}(\,) \times \left(\mathrm{Pbest_i} - \mathrm{S_i^K}\right) + \mathrm{c_2 Rand_2}(\,) \times \left(\mathrm{gbest} - \mathrm{S_i^K}\right) \tag{10}$$

$$\mathrm{S_i^{(K+1)}} = \mathrm{S_i^K} + \mathrm{V_i^{K+1}} \tag{11}$$

Where,

V_i^k is velocity of individual i at iteration k,

k is pointer of iteration, W is the weighing factor,

C_1, C_2 are the acceleration coefficients, $Rand_1(\,)$, $Rand_2(\,)$ are the random numbers between 0 & 1,

S_i^k is the current position of individual i at iteration k,

$P^{best}{}_i$ is the best position of individual i and

G^{best} is the best position of the group.

The c1 and c2 are coefficients of each particle towards pbest and gbest positions. values of acceleration coefficients allow particles from the target regions,we improve velocity of particles and their positions . Hence, the acceleration coefficients cl and c2 are often set to be 2 according to past experiences. The term c1rand1 () x (pbest, -Sk1) is called cognition part which shows the private thinking of the itself and the term c2Rand2( )×(gbest – Sk1) is called swarm influence or the social part which represents the collaboration among the particles.

In this paper, we improved the PSO method to facilitate a multi-objective approach. The important part in multi-objective particle swarm optimization is to determine the best global particle for each particle i of the particals. Since multi-objective optimization problems have a set of Pareto-optimal solutions as the optimum solutions, each particle of the population should use Pareto-optimal solutions as basis to select one of its global best particle .

In the procedure of the particle swarm optimization , the value of maximum allowed particle velocity Vmax . velocity determines the fitness of particles , in which regions they to be searched between the current position and the final position. The choice of a value for Vmax is often set at 10-20% of the dynamic range of the variable for each problem.

W is the inertia weight parameter used to provide balance between global and local explorations to particals ,from use of this less time required for optimal solution . Since W decreases linearly from about 0.9 to 0.4, the following weighing function is used in (10)

$$W = W_{max} - \frac{W_{max}-W_{min}}{iter_{max}} \times iter \qquad (12)$$

Where, W_{max} is initial weight of particals, W_{min} is final weight of particals, $Iter_{max}$ is the maximum iteration number and iter is the current iteration position.

B. CLASSICAL PARTICLE SWARM OPTIMIZATION (PSO)

In this section, to find better output the standers PSO also used CPSO to improve the velocity of the particals so constriction factor is used in the algorithms, so we used classical PSO [23],[27],The constriction factor is used in this algorithm given as

$$C = \frac{2}{\left|2-\emptyset-\sqrt{\emptyset^2-4\emptyset}\right|} \qquad (13)$$

Where, Ø is define as $4.1 \le \emptyset \le 4.2$

As $\emptyset$ increases, the factor c decreases and convergence becomes slower because population diversity is reduced.

Now the update its velocity using (14).

$$V_i^{(K+1)} = C[WV_i^K + c_1 Rand_1(\,) \times (Pbest_i - S_i^K) + c_2 Rand_2(\,) \times (gbest - S_i^K)] \qquad (14)$$

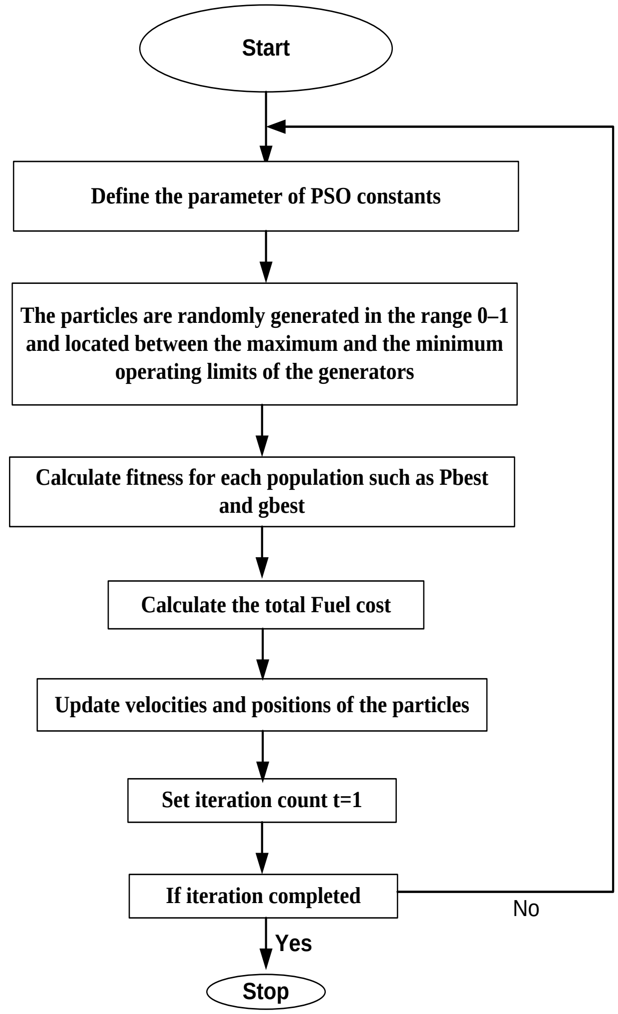

Fig. Algorithm For Eld With Emission Dispatch Problem Using Mrpso

IV. TEST DATA AND RESULTS

A. TEST DATA I

The first test results are obtained for 3-generator Systems in which all units with their Emission constraints. The unit characteristics data are given in Table I The load demand is 850 MW. The best solutions of the proposed PSO and CPSO.

TABLE I: Capacity, cost coefficients and Emission Coefficient of 3 generator systems

unit	a_1	b_1	c_1	P_i^{max}	P_i^{min}	*di*	*Ei*	*Fi*
1	0.05	2.47	105	200	50	0.0126	-1.355	22.983
2	0.05	3.51	44.1	400	100	0.01375	-1.249	137.37
3	0.06	3.88	40.6	600	100	0.00755	-0.0815	363.704

TABLE II: Results of Three Unit System

Unit Power Output	PSO	CPSO
P1(MW)	145.73	144.8978
P2(MW)	338.45	340.9597
P3(MW)	549.7817	547.8717
Power loss(MW)	183.043	183.7293
Total Power Output	1033.958	1033.7
Total Cost($/h)	9842.228	9839.228

B. TEST DATA II

The second test results are obtained for six-generating unit system in which all units with their Emission constraints. This system supplies a 1263MW load demand. The data for the individual units are given in Table III. The best solutions of the proposed PSO, CPSO are shown in Table IV.

TABLE III : Capacity, cost coefficients and Emission coefficient of 6 generator systems

unit	c_i	b_i	a_i	P_i^{min}	P_i^{max}	*di*	*Ei*	*fi*
1	756.7988	38.5397	.15247	10	125	.00419	.3274	13.8593
2	451.3251	46.1596	.10587	10	150	.00419	.3274	13.8593
3	1049.997	40.1516	.02083	35	225	.00683	-.5451	.0683
4	1234.531	38.3553	.03556	35	210	.00683	-.5451	.0683
5	1658.555	36.3981	.02112	130	325	.00451	-.5216	.0461
6	1356.659	38.7041	.0179	125	315	.00419	-.5116	.0461

TABLE IV: Generator output for six bus system

Unit Power Output	PSO	CPSO
P1(MW)	493.24	471.66
P2(MW)	114.63	140.03
P3(MW)	263.41	240.06
P4(MW)	139.71	149.97
P5(MW)	179.65	173.78
P6(MW)	84.83	99.97
Loss(MW)	12.46	12.31
Total Power Output	1275.46	1275.31
Total Cost($/h)	15489	15481.87

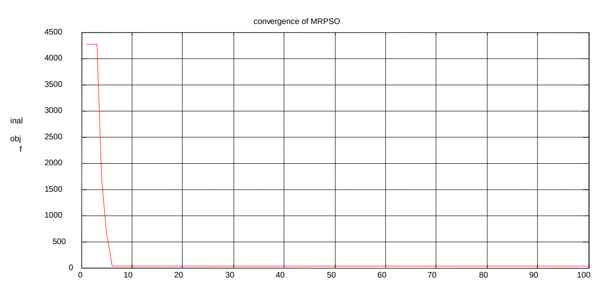

Figure.1. Fitness function of the conversion system for three generator system

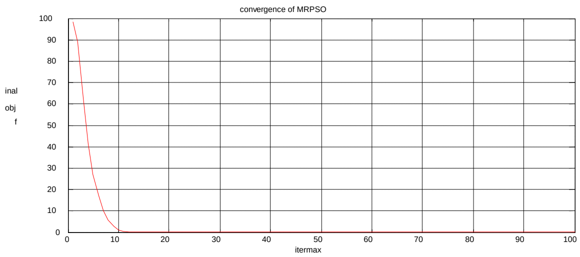

Figure.2. Fitness function of the conversion system for six generator system

To assess the efficiency of the proposed PSO and CPSO approaches in this paper, two case studies (3 and 6 thermal units or generators) of ELD problems with environmental emission were applied. The CPSO routine in this article is adopted using the Matlab Optimization Toolbox. All the programs were run on a 1.4-GHz, core-2 solo processor with 2GB DDR of RAM.

In each case study, 50 iteration were taken for each of the optimization. The constant used in this study was, acceleration coefficient used in this study are C1=C2=2, α=3.1-4.5, Wmax=0.9 and Wmin=0.4.

Fig.1, fig.2 and fig.3 show the improvement in each iteration for the three, six and fifteen generation unit system respectively.

V. CONCLUSIONS

This paper shows PSO and CPSO optimization is used for reliable and efficient economic power dispatch with ramp rate constraints. The proposed method has been applied to test case. The analysis have results that CPSO performs then other methods in terms of a better optimal solution, there is significant reduction in operating time and efficient power generated much improved speed of computation allows for additional searches to be made to increase the confidence in the solution. Overall, the CPSO algorithms have been very helpful to optimize problems in power systems.

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