ECONOMIC LOAD DISPATCH PROBLEM OPTIMIZATION USING TVAC-PSO

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Abstract

In this paper, the power and usefulness of the PSO with time varying characteristic is used to solve the proposed ELD problem with valve-point loading effect. The power generation organization has carefully generated power which is distributed to the buyer to fulfill their load demand and also not break the necessary conditions of the system.PSO is a population-based optimization technique is more effective than other evolutionary techniques and gives the optimum solution of nonlinear problems effectively. The main motive of economic load dispatch is to reduce the overall generation cost.The results are compared with basic PSO and other existing techniques in the literature.

Keywords-Fuel Cost, constraints,economic load **dispatch (ELD), particle swarm optimization(PSO), and optimization technique.**

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I. Introduction

The electrical power system is a parallel interconnected system and its main goal is to effectively achieve the minimum production cost, the height of reliable operation and safe operating conditions. The main function of ELD problem is to identify the generating units which are operating at that particular time when we have to analyze the system. According to the load demand of the consumers, available generating units are chosen in such a way to satisfy the consumers demand and same time no one generating units goes to overloaded. By using this idea can operate all generating units economically, and minimize the total generation cost of the generating units. When operating generating power plant many limitations are arises. Due to these limitations, the nature of ELD should be nonlinear in nature. Due to the presence of nonlinearity, it cannot be solved easily and needs some optimization techniques for the global solution of the ELD problem [1].

Some of articles described conventional methods like lambda iteration method, method based on gradient [2], Nonlinear programming [3], Mixed integer linear programming [4,5], Dynamic programming [8], LP(Linear programming) [7], QP(Quadratic programming) [9], Method of Lagrange relaxation [10], Direct search method [12], Newton-based techniques [11, 12] and Interior point methods [6,13] reported in the literature are used to solve such problems. But when they are working with these conventional methods found that, they have many complication which affect the solution of the problem such as programming algorithm of nonlinear programming is very difficult, similarly linear programming methods are very much affected by non-negative parameters, Quadratic programming needs quadratic type of mathematical formulation whereas in case of Newton method are very sensitive to initial conditions of the parameters and the interior point method is but suffers from bad initial execution and optimality standard.

To overcome the various problems of classical methods, many research articles suggest some new era technology based algorithm like simulated annealing (SA) [15], Tabu search (TS) [16], pattern search (PS) [17], Genetic algorithm [18] which is based on the theory of crossing of genetics chromosome, Differential evolution methods (DE) [19], Ant colony optimization [20], Neural network [21] based on the motion of the neurons of human mind and particle swarm optimization (PSO) [22, 23, 24, 26]. These all methods are robust in nature and give fast convergence results. Solutions obtained by these techniques are up to mark of a global solution. But time being it is also noticed that the new optimization methods also have some issues like evolutionary programming method have convergence so it take very long time to solve the nonlinear optimum problem, similar problem also arises in simulating algorithm, whereas Tabu search methods involve lots of difficulty in defining effective memory structures required and strategies, GA is effective algorithm but producing issue and this causes its convergence is slow and it give near global optimum solution of the nonlinear problem, and DE method having an excessive desire for updating principle and intrinsic differential property, hence trapped the computing process at local optima.

Recently a lot of research articles proposed a new optimization problem which is introduced by [26], is based on the social life of the animal, and used to search food in a group is called particle swarm optimization. This method is easy in formulation and implementation of the problem, no bar of making mathematical model formulation, need very low space of memory and give fast convergence results of the nonlinear problems.

This work uses PSO with time varying characteristic called TVAC PSO. Here accelerating coefficient are taking in such way to varying their values with iteration. This concept of varying acceleration coefficients can improve the movement of the particle in the search space and hence boost the results. This method is also unaffected of the property of nonlinearity so it can very easily solve the ELD problem with many limitations.

II. Problem Formulation

ELD is a standout amongst the most vital issues to be illuminated in the operation and arranging of a force framework the essential worry of an ED issue is the minimization of its goal capacity. The aggregate expense created that takes care of the demand and fulfills every singleother imperative related is chosen as the goal capacity.

The ED issue target capacity is figured scientifically in (1) and (2),

$$F_T = Min\, f(FC) \tag{1}$$

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

Where F_T is the main objective function, a_i, b_i and c_i are the cost coefficients.

III. Constraints

This model is subjected to the following constraints,

1) Power Balance Equation

For power balance, an equality constraint should be satisfied. The whole generated power should be identical to entire load demand plus the total losses,

$$\sum_{i=1}^{n} P_i = P_D + P_L \qquad (3)$$

Where, P_D is the total system demand and P_L is the total line loss.

2). Power Generation Limits

There is a limit on the amount of power which a unit can deliver. The power output of any unit should not exceed its rating nor should it be below that necessary for stable operation. Generation output of each unit should lie between maximum and minimum limits.

$$P_i^{\min} \le P_i \le P_i^{\max} \qquad (4)$$

Where, P_i is the output power of ith generator,

$P_i^{\min}$ And $P_i^{\max}$ are the minimum and maximum powers of generator i^{th}.

IV. Particle Swarm Optimization (PSO)

Particle swarm optimization is an energizing new technique in developmental calculation and a population based technique. PSO is persuaded to perform again of the conduct of social frameworks, for example, fish educating and winged animals rushing. It is a straightforward and capable advancement instrument which scrambles arbitrary particles, i.e., arrangements into the search space. These particles called swarms gather data from every cluster developed by their particular positions. The particles overhaul their positions utilizing the speed of articles. Position and speed are both upgraded in a heuristic way utilizing direction from particles' own particular experience and the experience of its neighbors.

The location and speed of the i^{th} particle of a d-dimensional search space can be represented as $P_i=(p_{i1},p_{i2},.........p_{id})$ and $V_i=(v_{i1},v_{i2}, ...v_{id},)$ respectively. On the basis of the value of the evaluation function, the best before position of a particle is testimony and characterize as $P_{besti}=(p_{i1},p_{i2}, ...p_{id})$, If the i^{th} particle is the best between all particles in the group so far, it is characterized as $P_{gbest}=g_{best}= (p_{g1},p_{g2}, ...p_{gd})$.

The particle updates its velocity and position using(5)and (6)

$$V_i^{(k+1)} = WV_i^K + c_1 Rand_1 \times (Pbest_i - S_i^K) + c_2 Rand_2 \times (gbest_i - S_i^K) \qquad (5)$$

$$S_i^{(k+1)} = S_i^K + V_i^{K+1} \qquad (6)$$

Where, V_i^k is velocity of individual i at iteration k, W is the weighting factor,

C_1, C_2 are the acceleration coefficients, $rand_1$, $rand_2$ are the random value among 0 & 1,

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

Pbest is the best position of individual i and

gbest is the best position of the group.

The coefficients c1 and c2 pull every molecule towards pbest and gbest positions. Low estimations of speeding up coefficients permit particles to move in zig-zag direction a long way from the objective areas, before being pulled back. Then again, high values result in unexpected development towards or past the objective areas. Subsequently, the increasing speed coefficients cl and c2 are regularly set to be 2 as indicated by past encounters. The term c1*rand1 x (pbest, -Sk1) is called molecule memory impact or comprehension part which speaks to the private thinking about itself and the term c2*rand2) × (gbest – Sk1) is called swarm impact or the social part which speaks to the joint effort among the particles.

In the method of the molecule swarm worldview, the estimation of greatest permitted molecule speed Vmax decides the determination, or wellness, with which districts are to be looked at the present position and the objective position. In the event that Vmax is too high, particles might fly past great arrangements. In the event that Vmax is too little, particles may not investigate adequately past neighborhood arrangements. In this way, the framework parameter Vmax has the advantageous impact of an anticipating blast and scales the investigation of the molecule look.

The decision of a quality for Vmax is frequently set at 10-20% of the dynamic scope of the variable for every issue.

W is the dormancy weight parameter which gives a harmony in the middle of worldwide and neighborhood investigations, in this manner requiring less cycle on a normal to discover an adequately ideal arrangement. Since W diminishes directly from around 0.9 to 0.4 all the time amid a run, the accompanying measuring capacity is utilized as a part of (5),

$$W = W_{\max} - \frac{W_{\max} - W_{\min}}{iter_{\max}} \times iter \qquad (7)$$

Where, W_{max} is the initial weight, W_{min} is the final weight,

$Iter_{max}$ is the maximum iteration number and iter is the current iteration position.

V. Time Varying Acceleration Coefficient (TVAC) PSO

In this section, for getting the better global solution, the traditional PSO algorithm is improved by adjusting the weight parameter, cognitive and social factors. Based on [15], the velocity of individual iteration of TVAC-PSO algorithm is rewritten as,

$$V_i^{(k+1)} = WV_i^K + c_1 Rand_1 \times (Pbest_i - S_i^K) + c_2 Rand_2 \times (gbest_i - S_i^K) \qquad (8)$$

Where,

$$c_1 = c_{1\max} - \frac{c_{1\max} - c_{1\min}}{iter_{\max}} \times iter \qquad (9)$$

$$c_2 = c_{2\max} - \frac{c_{2\max} - c_{2\min}}{iter_{\max}} \times iter \qquad (10)$$

c1min, c1max: initial and final cognitive factors and

c2min, c2max: initial and final social factors.

VI. Algorithm For ELD Problem Using TVAC-PSO

The algorithm for ELD problem with ramp rate generation limits employing TVAC-PSO for practical power system operationis given in following steps:-

Step1: -Initialization of the swarm: For a population size the Particles are randomly generated in the Range 0–1 and located between the maximum and the minimum operating limits of the generators.

Step2: - Initialize speed and position for all particles by arbitrarily set to the inside of their logical rang.

Step3:- Set iteration counter t=t+1.

Step4: - Evaluate the fitness for every molecule as indicated by the goal capacity.

Step5: - Compare particles fitness assessment with its pbest and gbest.

Step6: -Update velocity by using equation (8)

Step7: - Update position by using equation (6)

Step8: -Apply stopping criteria.

VII. Test Data and Results

TEST CASE 1

The test outcomes are accomplished for 3 generating unit producing the framework in which all units with their fuel cost coefficients. This framework supplies a heap interest of 850MW. The information for the individual units is given in Table no 1. Line losses are given in table no 2. The best result obtained by PSO and TVACPSO for different population size is shown in Table no 3 without considering line loss and table no 4 with considering line loss.

Table1: Capacity, cost coefficients and ramp- rate limits of three generating unit, Load 850MW.

Unit	a_i	b_i	c_i	P_i^{max}	P_i^{min}	Pi	UR_i	DR_i
1	0.004820	7.97	78	200	50	170	50	90
2	0.001940	7.85	310	400	100	350	80	120
3	0.001562	7.92	562	600	100	440	80	120

Table 2: Line loss coefficient (in mw^{-1}) for three generator system

B_{ij}	0.0006760	0.0000953	-0.0000507
	0.0000953	0.0005210	0.0000901
	-0.0000507	0.0000901	0.0002940
B_{i0}	-0.007660	-0.00342	0.01890
B_{00}	0.40357		

Table 3: Results of three generating unit system for the demand of 850MW, without line loss

Unit Power Output	PSO	TVACPSO
P1(MW)	121.94	115.911
P2(MW)	284.32	326.471
P3(MW)	443.742	407.634
Total Power Output	850	850
Total Cost($/h)	8203.881	8195.818
Computation time (Sec)	0.625	0.618

Table 4: Results of three generating unit system for the demand of 850MW, with consideration of line loss

Unit Power Output	PSO	TVACPSO
P1(MW)	146.03	152.34
P2(MW)	337.93	335.03
P3(MW)	550.17	546.21
Power loss(MW)	183.043	181.931
Total Power Output	1034.13	1033.58
Total Cost($/h)	11914.35	11874.95
Computation time (Sec)	0.783	0.773

Convergence characteristic of PSO and TVACPSO are shown in fig.1 and 2.

TEST CASE II

The test results are obtained for the six generating unit system in which all units with their fuel cost coefficients. This system supplies a load demand of 1263MW. The data for the individual units are given in Table no 5, the best result obtained by PSO and TVACPSO for different population size is shown in table no6 without considering line loss and in table no 7 with considering line loss.

Table 5: Capacity, cost coefficients and ramp- rate limits of six generating units, load 1263MW

Unit	c_i	b_i	a_i	P_i^{min}	P_i^{max}	P_i	UR_i	DR_i
1	240	7	0.0070	100	500	440	80	120
2	200	10	0.0095	50	200	170	50	90

3	220	8.5	0.0090	80	300	200	65	100
4	200	11	0.0090	50	150	150	50	90
5	220	10.5	0.0080	50	200	190	50	90
6	190	12.0	0.0075	50	120	110	50	90

Table 6: Results of six generating unit system for the demand of 1263 MW, without line loss.

Unit Power Output	PSO	TVACPSO
P1(MW)	481.4319	468.0026
P2(MW)	155.7025	190.0869
P3(MW)	273.6375	243.4789
P4(MW)	128.2156	118.9603
P5(MW)	127.5415	143.5623
P6(MW)	96.4713	98.9092
Total Power Output	1263	1263
Total Cost($/h)	15304.71	15294.62
Computation time	0.6361	0.6281

Table 7: Results of six generating system for the demand of 1263 MW, with considering line loss

Unit Power Output	PSO	GA[28]	TVACPSO
P1(MW)	453.5433	474.806	455.4115
P2(MW)	139.7384	178.636	145.0321
P3(MW)	292.9589	262.20	292.2161
P4(MW)	102.0806	134.282	109.4774
P5(MW)	186.2625	151.903	197.2296
P6(MW)	100.0028	74.18	75.2051
Loss	11.587	13.007	11.5718
Total Power Output	1274.587	1276.007	1274.572
Total Cost($/h)	15455.19	15459	15451.28
Computation time	0.7621		0.7530

VIII. Result Analysis

This work considered study of two cases of ELD problem for the analysis of PSO and TVAC PSO algorithm. All data are tested on a 2.3-GHz, core i3 processor with 2GB DDR of RAM.

The ELD data tested for the population size of 50, and taken 100 iterations. Some constants of PSO is taken are acceleration coefficients are c_1=c_2=2, W_{MAX}=0.9, and W_{MIN}=0.4.

Cost value is need to converted from dollar to Indian rupees that is (1$=66.42Rs).

The final result getting by proposed PSO and TVAC PSO for 3 thermal generating units is given in table 3 and 4. The minimum cost obtained by PSO and TVACPSO is 544901.776Rs/h and 544366.232Rs/h respectively, without considering of line loss. And with the loss, we get the results of PSO and TVACPSO is 791351.127Rs/h and 788734.179Rs/h respectively.

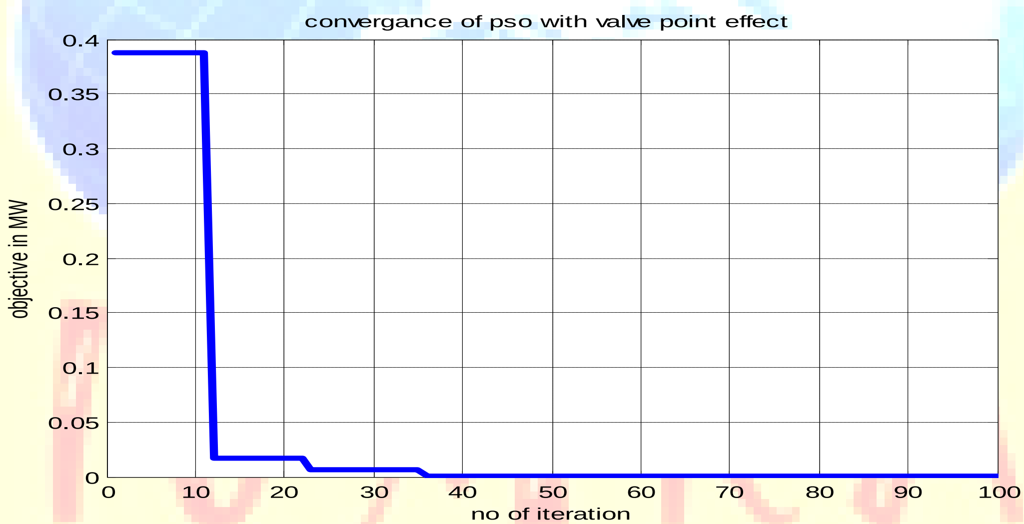

Fig.1 Convergence characteristic of TVAC PSO for 3 generating units

Similarly result obtained by TVAC-PSO for 6 thermal generating units shown in table 6 shows that minimum cost of PSO and TVAC PSO is 1016538.84Rs/hand 1015868.66Rs/h respectively for the population size of 50 without consideration of line loss. Similarly, minimum generation cost of 6 generating units by PSO, GA, and TVAC PSO with line loss is obtained as 1026533.72Rs/h, 1026786.78 Rs/h and 1026274.02Rs/h.

Convergence characteristic of TVACPSO for 6 thermal generating units is shown in figure 2.

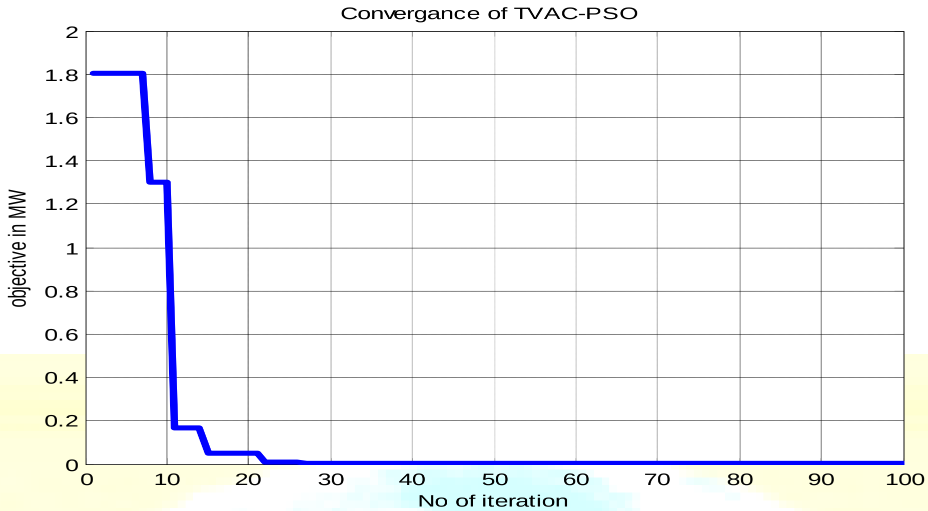

Fig.2. Convergence characteristic of TVAC PSO for 6 generating units

IX. Conclusions

This work proposed a PSO algorithm with time varying acceleration coefficients for the solution of power system economic dispatch with constraints. This method has been applied for 3 and 6 generating unit test case. The analysis results have expressed that TVAC-PSO performs better than the other methods in terms of a better optimal solution. However, the much-improved speed of computation analysis allows for additional searches to be made to increase the confidence in the solution. Overall, the TVAC PSO algorithms have been shown to be very helpful in studying optimization problems in power systems.

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