Moderate Random PSO Using For Economic Load Dispatch

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Abstract

Economic load dispatch (ELD) is an important optimization task in power system. It is the process of allocating generation among the committed units such that the constraints imposed are satisfied and the fuel cost is minimized. Particle swarm optimization (PSO) is a population- based optimization technique that can be applied to a wide range of problems but it lacks global search ability in the last stage of iterations. This paper used a novel PSO with a moderate-random-search strategy (MRPSO), which enhances the ability of particles to explore the solution spaces more effectively and increases their convergence rates. In this paper the usefulness of the MRPSO algorithm to solve the ELD problem is demonstrated through its application to three, six and fifteen generator systems with ramp rate limit constraints. The result shows MRPSO work efficiently and give optimal solution.

Key words:- ELD, Ramp rate, PSO, MRPSO.

1. Introduction

Electric utility system is interconnected to achieve the benefits of minimum production cost, maximum reliability and better operating conditions. The economic scheduling is the on-line economic load dispatch, wherein it is required to distribute the load among the generating units, 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 condition, ELD determines the power output 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]. ELD is used in real-time energy management power system control by most programs to allocate the total generation among the available units. ELD focuses upon coordinating the production cost at all power plants operating on the system.

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 [7], Linear programming [6], Quadratic programming [8], Lagrange relaxation method [9], Newton-based techniques [10] and Interior point methods [5], 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. Quadratic programming is a special form of nonlinear programming which has some disadvantages associated with piecewise quadratic cost approximation. Newton-based method has a drawback of the convergence characteristics that are sensitive to initial conditions. The interior point method is computationally efficient but suffers from bad initial termination and optimality criteria.

Recently, different heuristic approaches have been proved to be effective with promising performance, such as evolutionary programming (EP) [11], simulated annealing (SA) [12], Tabu Search (TS) [13], pattern search (PS) [14], Genetic algorithm (GA) [15], [16], Differential evolution (DE) [17], Ant colony optimization [18], Neural network [19], particle swarm optimization (PSO) [20], [21], [22], SOHPSO[23], Modified PSO[24], classical PSO[26], MRPSO[27], WIPSO[28], MOPSO[29]. Although the heuristic methods do not always guarantee discovering globally optimal solutions in finite time, they often provide a fast and reasonable 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 problem dependent. GA sometimes lacks a strong capacity of producing better offspring and causes slow convergence near global optimum, sometimes may be trapped into local optimum. DE greedy updating principle and intrinsic differential property usually lead the computing process to be trapped at local optima.

Particle-swarm-optimization (PSO) method is a population-based Evolutionary technique and it is inspired by the emergent motion of a flock of birds searching for food. In comparison with other EAs such as GAs and evolutionary programming, the PSO has comparable or even superior search performance with faster and more stable convergence rates but its lacks global search ability in the last stage of iterations. This problem can be solved by using moderate random search technique with PSO. In this paper used MRPSO to solve the ELD problem. It enhance the global search ability and gives more opportunity of the particles to explore the solution space than is standard PSO.

The proposed method focuses on solving the economic load dispatch with Generator Ramp Rate Limits constraint. The feasibility of the proposed method was demonstrated for three, six and fifteen bus system. The results are obtained through the proposed approach and compared with other PSO methods reported in recent literatures.

2. Economic Dispatch problem Formulation

2.1. Basic formulation of ED

ED is one of the most important problem to be solved in the operation and planning of a power system. the primary concern of an ED problem is the minimization the total cost of generation(objective function) in such a way that meets the demand and satisfies all constraints associated is selected as the objective function.

The ED problem objective function is formulated mathematically in (1) and (2).

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

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

$$D = \sum_{i=1}^{n} P_i - P_D - P_L \quad (3)$$

Where, F_T is the objective function,
a_i, b_i and c_i are the cost coefficients.
D is power equilibrium; P_D and P_L represent total demand power and the total transmission loss of the transmission lines respectively.

2.2. Constraints

2.2.1 Real Power Balance Equation

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

$$\sum_{i=1}^{n} P_i = P_{Demand} + P_L \quad (4)$$

$$P_L = \sum_{i=1}^{n} \sum_{j=1}^{n} P_i B_{ij} P_j + \sum_{i=1}^{n} B_{i0} P_i + B_{00} \quad (5)$$

Where, P_{Demand} is the total system demand and P_{Loss} is the total line loss.
B_{ij} =ijth element of loss coefficient symmetric matrix B,
B_{i0} =ith element of the loss coefficient vector and
B_{00} =loss coefficient constant.

2.2.2. Unit Operating 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.

$$P_i^{min} \le P_i \le P_i^{max} \quad (6)$$

Where, Pi is the output power of i_{th} generator ,
$P_{i,min}$ and $P_{i,max}$ are the minimum and maximum power outputs of generator i respectively.

2.2.3. Ramp Rate Limit

According to the operating increases and operating decreases of the generators the ramp rate limit constraints described in eq. (7) & (8).
1) As generation increases

$$P_i(t) + P_i(t-1) \le UR_i \quad (7)$$

2) As generation decreases

$$P_i(t-1) - P_i(t) \ge DR_i \quad (8)$$

When the generator ramp rate limits are considered, the operating limits for each unit, output is limited by time dependent ramp up/down rate at each hour as given below.

$P_i^{min}(t)$=max($P_i^{min}, P_i(t-1) - DR_i$) and
$P_i^{max}(t)$= min($P_i^{max}, P_i(t-1) - UR_i$).

$$P_i^{min}(t) \le P_i(t) \le P_i^{max}(t) \quad (9)$$

Where, $P_i(t)$ =current output power of i_{th} generating unit,
$P_i(t-1)$ =Previous operating point of the i_{th} generator,
DR_i =Down ramp rate limit (MW/time period) and
UR_i =Up ramp rate limit (MW/time period).

3. Overview of Some PSO Strategies

A number of different PSO strategies are being applied by researchers for solving the economic load dispatch problem and other power system problems. Here, a short review of the significant developments is presented which will serve as a performance measure for the MRPSO technique [27] applied in this paper.

3.1. Standard particle swarm optimization (PSO)

Particle swarm optimization was first introduced by Kennedy and Eberhart in the year 1995. It is an exciting new methodology in evolutionary computation and a population-based optimization tool. PSO is motivated from the simulation of the behavior of social systems such as fish schooling and birds flocking. It is a simple and powerful optimization tool which scatters random particles, i.e., solutions into the problem space. These particles, called swarms collect information from each array constructed by their respective positions. 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.

The position and velocity vectors of the ith particle of a d-dimensional search space can be represented as $P_i=(p_{i1},p_{i2},\ldots\ldots\ldots p_{id})$ and $V_i=(v_{i1},v_{i2},\ldots\ldots\ldots v_{id},)$ respectively. On the basis of the value of the evaluation function, the best previous position of a particle is recorded and represented as $P_{besti}=(p_{i1},p_{i2},\ldots\ldots\ldots p_{id})$, If the gth particle is the best among all particles in the group so far, it is represented as $P_{gbest}=g_{best}=(p_{g1},p_{g2},\ldots\ldots\ldots p_{gd})$.

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

$$V_i^{(K+1)} = WV_i^K + c_1 Rand_1() \times (Pbest_i - S_i^K) + c_2 Rand_2() \times (gbest - S_i^K) \quad (10)$$

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

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 coefficients c_1 and c_2 pull each particle towards pbest and gbest positions. Low values of acceleration coefficients allow particles to roam far from the target regions, before being tugged back. on the other hand, high values result in abrupt movement towards or past the target regions. Hence, the acceleration coefficients c_1 and c_2 are often set to be 2 according to past experiences. The term c_1rand_1 () x (pbest, $-S^k_1$) is called particle memory influence or cognition part which represents the private thinking of the itself and the term $c_2Rand_2(\,)\times(gbest - S^k_1)$ is called swarm influence or the social part which represents the collaboration among the particles.

In the procedure of the particle swarm paradigm, the value of maximum allowed particle velocity V^{max} determines the resolution or fitness, with which regions are to be searched between the present position and the target position. If V^{max} is too high, particles may fly past good solutions. If V^{max} is too small, particles may not explore sufficiently beyond local solutions. Thus, the system parameter V^{max} has the beneficial effect of preventing explosion and scales the exploration of the particle search. The choice of a value for V^{max} is often set at 10-20% of the dynamic range of the variable for each problem.

W is the inertia weight parameter which provides a balance between global and local explorations, thus requiring less iteration on an average to find a sufficiently optimal solution. Since W decreases linearly from about 0.9 to 0.4 quite often during a run, the following weighing function is used in (10)

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

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.

3.2. CLASSICAL PSO

In this section, for getting better solution the standard PSO algorithm, used classical PSO [26],The constriction factor is used in this algorithm given as

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

Where, Ø is define as $4.1\leq Ø\leq 4.2$
As Ø increases, the factor c decreases and convergence becomes slower because population diversity is reduced.

Now the update its velocity using (14).

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

3.3. WEIGHT IMPROVED PSO (WIPSO)

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 the velocity of individual i of WIPSO algorithm [28] is rewritten as,

$$V_i^{(K+1)} = w_{new} V_i^K + c_1 Rand_1() \times (Pbest_i - S_i^K) + c_2 Rand_2() \times (gbest - S_i^K) \quad (15)$$

Where,

$$W = W_{max} - \frac{W_{max} - W_{min}}{iter_{max}} \times iter \quad (16)$$

$$w_{new} = w_{min} + w \times rand_3 \quad (17)$$

$$c_1 = c_{1max} - \frac{c_{1max} - c_{1min}}{iter_{max}} \times iter \quad (18)$$

$$c_2 = c_{2max} - \frac{c_{2max} - c_{2min}}{iter_{max}} \times iter \quad (19)$$

Where , wmin, wmax: initial and final weight,
c1min, c1max: initial and final cognitive factors and
c2min, c2max: initial and final social factors.

3.4. MRPSO

MRPSO was first introduced by Hao Gao and Wenbo in the year 2011[27], In order to enhance the global search ability of the PSO but not slow down its convergence rate, we used a new PSO algorithm with an MRS strategy. In this algorithm used only position update and no need of updating velocity .

The position $S_i^{(K+1)}$ of the i_{th} particle at the (K + 1)th iteration can be calculated using (20), (21).

$$S_i^{K+1} = P_d + \propto \lambda(m_{besti} - S_i^K) \quad (20)$$

$$m_{besti} = \sum_{i=1}^{S} \frac{P_{best}}{S} \quad (21)$$

Where, S denotes the population size in the MRPSO.
The parameter α is obtained by changing α from 0.45 to 0.35 with the linear-decreasing method during iteration,
Pd is the attractor moving direction of particles, it is given as (22).

$$P_d = rand_0 P_{best} + (1 - rand_0) g_{best} \quad (22)$$

Where, $rand_0$ is a uniformly distributed random variable within [0, 1].

$$\lambda = (rand_1 - rand_2)/rand_3 \quad (23)$$

Where, $rand_1$ and $rand_2$ are two random variables within [0, 1] , and $rand_3$ is a random variable within [−1, 1].

4. Algorithm for ED Problem Using MRPSO

The algorithm for ED problem with ramp rate generation limits employing MRPSO for practical power system operation is 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 velocity and position for all particles by Randomly set to within their legal rang.
Step3:-Set generation counter t=1.
Step4:- Evaluate the fitness for each particle according to the objective function.
Step5:-Compare particles fitness evaluation with its Pbest and Gbest.
Step6:-Update position by using (20).
Step7:- Apply stopping criteria.

5. Case Study

5.1. Test Case I

The first test results are obtained for 3-generator Systems in which all units with their ramp-rate limits. The unit characteristics data are given in Table 1 The load demand is 850 MW. The *B* loss coefficients are given in Table 2. The best solutions of the proposed MRPSO, PSO, CPSO & WIPSO methods are shown in Table 6.

Table 1
Capacity, cost coefficients and ramp- rate limits of 3 generator systems.

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
B coefficient (in mw^{-1}) for 3 generator system

0.0006760	0.0000953	-0.0000507
0.0000953	0.0005210	0.0000901
-0.0000507	0.0000901	0.0002940

Bio = [-0.007660 -0.00342 0.01890] and Boo=0.40357.

5.2. Test Case II

The second test results are obtained for six-generating unit system in which all units with their ramp-rate limits. This system supplies a 1263MW load demand.

Table 3
Capacity, cost coefficients and ramp- rate limits of 6 generator systems.

Unit	c_i	b_i	a_i	P_i^{min}	P_i^{max}	*Pi*	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

The data for the individual units are given in Table 3. The *B* matrix of the transmission loss coefficient is given in table 4. The best solutions of the proposed MRPSO, PSO, CPSO and WIPSO methods are shown in Table 7.

Table 4
B(10^{-4}) coefficients (in mw^{-1}) for six generator systems

0.17	0.12	0. 7	-0.1	-0.5	0.02
0.12	0.14	0.09	0.01	-0.06	0.01
0.07	0.09	0.31	.000000	-0.10	0.06
-0.01	0.01	0.0000	2.4	-0.06	0.08
-0.05	-0.06	-0.10	-0.06	1.29	0.02
-0.02	-0.01	-0.06	-0.8	-0.2	1.50

Bio=10^{-4}[-0.3908 -1.297 7.047 0.5910 2.161 -6.635]

Boo=0.0056.

5.3. Test Case III

The third test results are obtained for fifteen-generating unit system in which all units with their ramp-rate limits. This system supplies a 2650 MW load demand.

Table 5
Capacity, cost coefficients and ramp- rate limits of 6 generator systems.

Unit	c_i	b_i	a_i	P_i^{min}	P_i^{max}	*Pi*	UR_i	DR_i
1	671	10.1	0.000299	150	455	400	80	120
2	574	10.2	0.000183	150	455	300	80	120
3	374	8.8	0.001126	20	130	105	130	130
4	374	8.8	0.001126	20	130	100	130	130
5	461	10.4	0.000205	150	470	90	80	120
6	630	10.1	0.000301	135	460	400	80	120
7	548	9.8	0.000364	135	465	350	80	120
8	227	11.2	0.000338	60	300	95	65	100
9	173	11.2	0.000807	25	162	105	60	100
10	175	10.7	0.001203	25	160	110	60	100
11	186	10.2	0.003586	20	80	60	80	80
12	230	9.9	0.005513	20	80	40	80	80
13	225	13.1	0.000371	25	85	30	80	80
14	309	12.1	0.001929	15	55	20	55	55
15	323	12.4	0.004447	15	55	20	55	55

The data for the individual units are given in Table 6. The best solutions of the proposed MRPSO, PSO, CPSO and WIPSO methods are shown in Table 8.

Table 6
Results of Three generator system (100 trails)

Unit Power Output	*PSO*	*CPSO*	*WIPSO*	*MRPSO*
P1(MW)	145.73	144.8978	146.408	143.34
P2(MW)	338.45	340.9597	343.45	346.45
P3(MW)	549.7817	547.8717	543.563	534.565
Power loss(MW)	183.043	183.7293	183.689	183.645
Total Power Output	1033.958	1033.7	1033.421	1033.355
Total Cost($/h)	9842.228	9839.228	9834.781	**9833.605**
Computation time (sec.)	0.368939	0.356130	0.479264	0.350648

Table 7
Generator output for six generator system (100 trails)

Unit Power Output	*PSO*	*CPSO*	*WIPSO*	*MRPSO*
P1(MW)	493.24	471.66	454.39	462.6651
P2(MW)	114.63	140.03	164.279	195.36
P3(MW)	263.41	240.06	246.223	237.2409
P4(MW)	139.71	149.97	123.21	98.00
P5(MW)	179.65	173.78	167.22	197.7415
P6(MW)	84.83	99.97	120.00	83.4235
Loss	12.22	12.38	12.24	12.11
Total Power Output	1275.46	1275.31	1275.3	1275.116
Total Cost($/h)	15489	15481.87	15453.13	**15441.9**
Computation Time(sec)	0.524359	0.479387	0.459492	0.464212

6. Result and Analysis

The Economic load dispatch problem solved by using the MRPSO and its performance is compared with PSO, CPSO and WIPSO. Data given for different generating units in Table 1, Table 3 and Table 5. The result obtained for these data by PSO, CPSO, WPSO and MRPSO. The program for these pso to solve ELD problem are developed in Matlab 7.5 on a 1.4-GHz, core-2 solo processor with 2GB DDR of RAM.

The constants used in this study was, acceleration coefficient c1=c2=2, W_{max}=0.9 and W_{min}=0.4.

The performance of MRPSO in this study the value of α taken 3.5.

The convergence behavior of MRPSO was tested for Economic load dispatch with ramp rate constraint on different cases. The first test case is taken for three-generating units, the data for first test case given in table 1, with ramp rate limit constraints. The B-coefficients are given in table 2 for calculation of power loss of the considered system. For testing of this case a total load of 850 MW was taken. The result obtained by PSO, CPSO, WIPSO and MRPSO is given in table 6. The result of test data shows the best value of cost in this test case calculated by MRPSO is $ 9833.605/h and its computation time is 0.350648 sec., total power loss calculated by MRPSO in this test case is 183.645 MW and obtained total generated output power is 1033.355 MW. All these result obtained for test case shows that MRPSO take less computing time and obtain least value of cost and loss of the 3 generating system.

The second test case is taken for six-generating units, the data for second test case given in table 3, with ramp rate limit constraints. The B-coefficients are given in table 4 for calculation of power loss of the considered system. For testing of this case a total load of 1250 MW was taken. The result obtained by PSO, CPSO, WIPSO and MRPSO is given in table 7. The result of test data shows the best value of cost in this test case calculated by MRPSO is $ 15441.9/h and its computation time is 0.464212 sec., total power loss calculated by MRPSO in this test case is 12.11 MW and obtained total generated output power is 1275.116 MW. All these result obtained for second test case shows that MRPSO take less computing time and obtain least value of cost and loss of the 6 generating system.

The third test case is taken for fifteen -generating units, the data for second test case given in table 5, with ramp rate limit constraints. In this case not considered the loss of the system. For testing of this case a total load of 2650 MW was taken. The result obtained by PSO, CPSO, WIPSO and MRPSO is given in table 8. The result of test data shows the best value of cost in this test case calculated by MRPSO is $ 32462.15/h and its computation time is 0.46114 sec., obtained total generated output power is 2650 MW. All these result obtained for thired test case shows that MRPSO take less computing time and obtain least value of cost.

Table 8
Generator output for 15 generator system (100 trails)

Unit Power Output	*PSO*	*CPSO*	*WIPSO*	*MRPSO*
P1(MW)	454.3	454.98	455	422
P2(MW)	452.8	455	448.3	455
P3(MW)	132	130	130	131
P4(MW)	129	130	130	131.6
P5(MW)	336.9	335.02	265.02	341
P6(MW)	423	424.25	460	460
P7(MW)	462.5	464.98	465	465
P8(MW)	61.7	60	62	70
P9(MW)	24.9	25	25	21.6
P10(MW)	20.98	20	20	20
P11(MW)	19.08	20	59	20
P12(MW)	73.5	75	75	63.2
P13(MW)	25.08	25	25	20.6
P14(MW)	16.5	15	15	13.89
P15(MW)	17.06	15	15	15
Total Power Output	2649.30	2649.23	2649.32	2650.0
Total Cost($/h)	32476.7	32467.77	32464.03	**32462.15**
Computation time (sec.)	04821058	0.422924	0.613154	0.461147

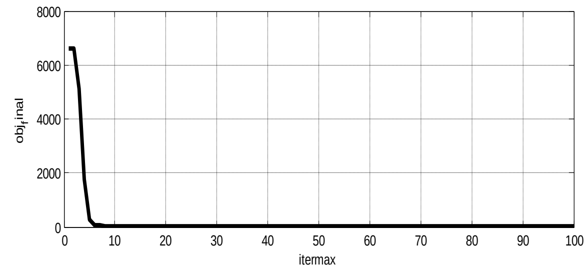

Figure.1. Fitness function of the conversion system for three generator system

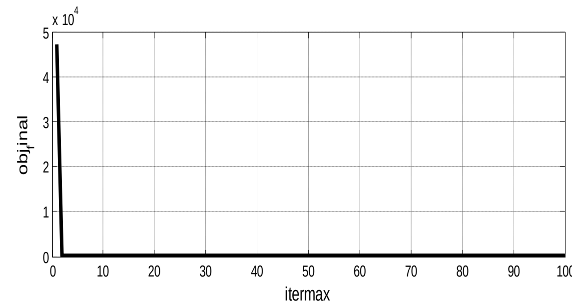

Figure.2. Fitness function of the conversion system for six generator system

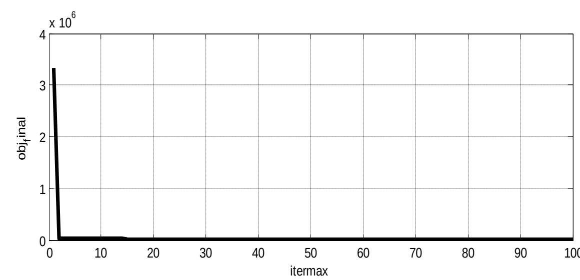

Figure.3. Fitness function of the conversion system for fifteen generator system

Figure.1, figure.2 and figure.3 show the graph between object final V/s itermax in each iteration for the 3,6 and 15 generation unit system respectively.

7. Conclusion

In This paper MRPSO is used to solve the economic dispatch with ramp rate limit constraints. The test results obtained by MRPSO clearly demonstrated that it is capable of achieving global solution, it is computationally efficient and give better optimal results (minimum cost) than other PSO methods. Overall, the MRPSO algorithms have been shown to be very helpful in studying optimization problems in economic load dispatch problem.

References

[1] M.E. EI-hawary & G.S. Christensen, “Optimal economic operation of Electrical power system,” New York, Academic, 1979.

[2] Mezger Alfredo J & Katia de Almeida C, "Short term hydro thermal scheduling with bilateral traction via bundle method," International Journal of Electrical power & Energy system 2007, 29(5), pp-387-396.

[3] Martinez Luis Jose, Lora Trancoso Alicia & Santos Riquelme Jesus, "Short term hydrothermal coordination based on interior point nonlinear programming and genetic Algorithm,"IEEE porto power Tech Confrence, 2001.

[4] M. Gar CW, Aganagic JG,Tony Meding Jose B & Reeves S, "Experience with mixed integer linear programming based approach on short term hydrothermal scheduling," IEEE transaction on power system 2001, 16(4), pp.743-749.

[5] G.Torres and V. Quintana, "On a non linear multiple-centrality corrections interior-point method for optimal power flow," IEEE. transaction on power system, vol.16, no2, 2001, pp.222-228.

[6] K.Ng and G.Shelbe, " Direct load control –a profit-based load management using linear programming," IEEE transaction on power system,vol.13,no.2, 1998, pp.688-694.

[7] Shi CC, Chun HC, Fomg IK & Lah PB., " Hydroelectric generation scheduling with an effective differential dynamic programming algorithm," IEEE transaction on power system 1990, 5(3), pp.737-743.

[8] Erion Finardi C, silva Edson LD, & Laudia sagastizabal CV., "Solving the unit commitment problem of hydropower plants via Lagrangian relaxation and sequential quadratic programming," Computaional & Applied Mathematics 2005, 24(3).

[9] Tkayuki S & Kamu W., " Lagrangian relaxation method for price based unit commitment problem," Engineering optimization taylor Francis 2004, pp. 36-41.

[10] D.I. sun, B.Ashley,B.Brewer,A.Hughes and W.F. Tinney, " Optimal power flow by Newton Aproach," IEEE transaction on power system, vol.103, 1984, pp.2864-2880.

[11] Nidhul Sinha, R.Chakrabarti & P.K. Chattopadhyay, " Evolutionary programming techniques for Economic load Dispatch," IEEE transactions on Evolutionary Computation, Vol.7, No1, 2003, pp.83-94.

[12] K.P. Wong & C.C. Fung, "Simulated annealing based economic dispatch algorithm," proc. Inst. Elect. Eng. C., Gen., transm.,Distrib.,vol.140, no.6, Nov.1993, pp.505-519.

[13] W.M. Lin, F.S. Cheng & M.T. Tsay, "An improved Tabu search for economic dispatch with multiple minima," IEEE transaction on power system , vol.17, no.2, 2002, pp.108-112.

[14] J.S. Al-Sumait, A.K. Al-Othman & J.K. Sykulski, " Application of pattern search method to power system valve point economic load dispatch," Elect. Power energy system, vol.29, no.10, 2007, pp.720-730.

[15] D.C.Walter & G.B.Sheble, " genetic algorithm solution of economic dispatch with valve point loading," IEEE transaction on power system, vol.8, no.3, 1993, pp.1325-1332.

[16] Tarek Bouktir, Linda Slimani & M.Belkacemi, " A genetic algorithm for solving for the optimal power flow problem," Leonardo journal of sciences, Issue-4, 2004, pp.44-58.

[17] K. Vaisakh & L.R. Srinivas, "Differential Approach for optimal power flow solutions," Journals of theoretical and applied information Technology, 2005-08, pp. 261-268.

[18] Boumediene Allaoua & Abedellah Laoufi, "Optimal power flow solution Unsing ant manners for electrical network," Advance in Electrical & Computer engg.," Vol.9, 2009, pp.34-40.

[19] L.L. Lai & Mata Prasad, "Application of ANN to economic load dispatch," proceeding of 4th international conference on Advance in power system control, Operation and management, APSCOM-97, Hong-Kong, nov-1997, pp.707-711.

[20] J.Kennedy & R.C. Eberhart, "Particle Swarm Optimization," proceeding of IEEE international conference on Neural networks , Vol.4, 1995, pp. 1942-1948.

[21] C.H. Chen & S.N. Yeh, " PSO for Economic power dispatch with valve point effects," IEEE PES transmission & Distribution conference and Exposition Latin America, Venezuela, 2006.

[22] K.S. Swarup, " Swarm intelligence Approach to the solution of optimal power flow," Indian Institute of science, Oct-2006, pp. 439-455.

[23] K.T. Chaturvedi, Manjaree pandit & Laxmi Srivastava, "Self Organizing Hierachical PSO for nonconvex economic load dispatch," IEEE transaction on power system, vol.23, no.3, Aug. 2008, pp.1079-1087.

[24] Adel Ali Abou EL-Ela & Ragab Abdel-Aziz EI-Sehiemy, " Optimized Generation costs using modified particle Swarm optimization version," Wseas transactions on power systems, Oct-2007, pp.225-232.

[25] A.Pereira-Neto, C. Unsihuay & O.R. Saavedra, " Efficient evolutionary strategy optimization procedure to solve the nonconvex economic dispatch problem with generator constraints," IEE proc. Gener. Transm. Distributed, vol.152, no.5, Sept 2005, pp.653-660.

[26] R.C. Eberhart & Y. Shi, " Comparing inertia weights and constriction factor in PSO," in proc. Congr. Evolutionary computation, 2000, vol.1, pp.84-88.

[27] Hao Gao & Wenbo Xu, " A new particle swarm algorithm and its globally convergent modifications," IEEE transactions on systems, man, and cybernetics—Part B: cybernetics, vol. 41, no. 5, october 2011, pp.1334-1351.

[28] Phan Tu Vu, Dinhlungle & Joef, " A Novel weight-Improved Particle swarm optimization algorithm for optimal power flow and economic load dispatch problem," IEEE confrence, 2010, pp.1-7.

[29] H. Shayeghi & A. Ghasemi, " Application of MOPSO for economic load dispatch solution with transmission losses," International journal on technical and physical problems of Engineering, Issue 10, vol. 4, 2012, pp. 27-34.