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Solution of Dynamic Economic Load Dispatch (DELD) Problem with Valve Point Loading Effects and Ramp Rate Limits Using PSO

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Abstract

Dynamic economic load dispatch (DELD) is one of the major operational decisions in power system operation and control. It is a Dynamic problem due to dynamic nature of Power system and the large variation of load demand. This absolute problem is normally solved by discretisation of the entire dispatch period into a number of small time intervals over which the load is assumed to be constant and the system is considered to be in temporal steady state. This paper presents particle swarm optimization technique to solve the DELD problem for the determination of the global or near global optimum dispatch solution. To illustrate the effectiveness of the proposed approach, three test systems consisting of 5,10 and 15 generating units, with incorporation of load balance constraints, operating limits, valve point loading, ramp constraints and network lossesare considered and tested. The comparison of numerical results demonstrate the performance and applicability of the proposed method.

Keywords: *Dynamic economic load dispatch (DELD), Particle Swarm Optimization, Valve - point loading effect, Ramp Rate Limits.*

1. Introduction

Problem of allocating the Customer's load demands among the available thermal power generating units in an economic, secure and reliable way has received considerable attention since 1920 or even earlier. This problem is known as Economic Load Dispatch. Dynamic Economic Dispatch (DELD) is an extension of the Conventional Economic dispatch problem used to determine the optimal generation schedule of on-line generators. Due to the ramp – rate constraints of a generator, the operational decision at hour t may affect the operational decision at a later hour. For a power system with binding ramp-rate limits, these limits must be properly modeled in production simulation. The DELD is not only the most accurate formulation of the economic dispatch problem but also the most difficult dynamic optimization problem. The first paper in the area of optimal dynamic dispatching (ODD) appeared in 1972 by Bechert and Kwatny [1] and followed by [2] – [6]. In general, the DELD problem has been solved by splitting the entire scheduling period into small intervals. The economic schedule of thermal units for each interval is determined subject to power balance constraint of the interval and unit operational constraints. A survey of literature on the DELD solution methods reveals that the various numerical optimization techniques have been employed to approach the DELD problem [7]. It is observed that the traditional and heuristic methods have some limitations to solve DELD problems[8-18]. The traditional methods suffer with large execution time and the heuristic methods are unable to find the optimal solution within the reasonable execution time due to their heuristic nature.

Recent researches have been directed towards the application of particle swarm optimization (PSO) technique to solve DELD problem[12]. The PSO is an efficient global search technique and may be used to find optimal or near optimal solutions to numerical and qualitative problems. It is easy to implement in most programming languages and has been proved to be quite effective and reasonably quick when applied to a diverse set of optimization problems. In this paper the PSO based DELD algorithm is presented for the determination of global or near global optimum dispatch solution. In the proposed method, the operating limit constraints transmission losses with B-matrix Co-efficients and valve point loading effects are fully incorporated. It has been shown that the algorithm is capable of finding the global or near global optimum solutions for large optimization problems. The proposed algorithm has been implemented in MATLAB on Pentium® D, 2.7 GHZ personnel computers with 1 GB RAM.

2. Mathematical Formulation

The main objective of DELD problem is to determine the optimal schedule of output powers of online generating units with predicted power demands over a certain period of time to meet the power demand at minimum operating cost. The mathematical formulation of DELD problem is as follows.

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2.1 Objective Function

The fuel cost function of the generating unit is expressed as a quadratic function of real power generation. The objective function of the DELD problem is formulated as:

$$Min\ C_T = \sum_{t=1}^{T}\sum_{i=1}^{N} C_{it}(P_{Git}) \tag{1}$$

Where C_T is the total operating cost over the whole dispatch period; T is the number of hours in time horizon; N is the number of dispatchable units; C_{it} (P_{Git}) is the fuel cost of i^{th} unit at time 't' and is a function of its real power output at time 't'.

The thermal plant can be expressed as Input – Output models (Cost function), where the input is the electrical power output of each unit and the output is the fuel cost.

The fuel cost C_i of generating unit'i'at any time interval 't' is normally expressed as a quadratic function as

$$C_{it}(P_{Git}) = a_i + b_i P_{Git} + C_i P_{Git}^2 \tag{2}$$

When the effect of valve point loadings taking into account, the fuel cost function of i^{th} generating unit is expressed as the sum of a quadratic and a sinusoidal function in the following form :

$$C_{it}(P_{Git})=a_i+b_iP_{Git}+c_iP_{Git}^2+ |e_i \mathrm{Sin}\{f_i(P_{itmin}–P_{it})\}| \tag{3}$$

Where a_i, b_i, c_i are the fuel cost co-efficients of i^{th} unit; e_i, f_i, are the fuel cost Co-efficients of i^{th} unit with valve point effects; P_{Git} is the power output of i^{th} unit in MW.

The minimization of above fuel cost function is subjected to the following constraints.

2.2 Equality Constraint

Real Power balance Constraint

This constraint is based on the principle of equilibrium that the total generation at any time interval 't' should satisfy the load demand at the interval 't' and the transmission loss. This constraint is mathematically expressed as,

$$\sum_{i=1}^{N} P_{Git} – P_{Dt} – P_{Lt} = 0 \tag{4}$$

For $t = 1, 2, \ldots\ldots\ldots\ T$

where

P_{Dt} is the forecasted total power demand at time t;

P_{Lt} is the transmission power loss at time t.

The general form of the loss formula (George's formula) using B – co-efficients is

$$P_{Lt} = \sum_{i=1}^{N}\sum_{j=1}^{N} P_{Git} B_{ij} P_{Gjt} \tag{5}$$

Where

P_{Git}, P_{Gjt} are real power injection at i^{th} and j^{th} buses at time '*t*' respectively;

B_{ij} is the loss co - efficients which are constants under certain assumed operating conditions and

N is the number of generator buses.

2.3 Inequality Constraints

Generator operational Constraints

The generating unit operational constraints such as minimum / maximum generating limit, ramp rate limits are as follows.

(i) Real power operating (Generator Capacity) Constraints

$$P_{Git\,min} \leq P_{Git} \leq P_{Git\,max} \qquad \text{for} \quad i = 1, 2, \ldots\ldots\ldots.. N$$
$$t = 1, 2, \ldots\ldots\ldots.. T \qquad (6)$$

Where P_{Gitmin} and P_{Gitmax} are the minimum and maximum real power output of generator ‘i’ in MW that can supply at time ‘t’ respectively.

(ii) Spinning Reserve Constraints

$$\sum_{i=1}^{N} P_{Git\,max} \geq SR_t$$

$$\text{for } t = 1, 2, \ldots T \qquad (7)$$

Where P_{Gitmax} is the maximum real power output that the i^{th} generator can supply at time t and SR_t is the forecasted spinning reserve demand at time t.

(iii) Generating unit ramp rate limits

The generator constraints due to ramp rate limits of generating units are given as

a) When generation increases

$$P_{Git} - P_{Gi\,(t-1)} \leq UR_i$$

b) When generation decreases

$$P_{Gi(t-1)} - P_{Git} \leq DR_i \qquad (8)$$

$$\text{For } i = 1,2,\ldots\ldots N$$

Where UR_i and DR_i are the ramp-up and ramp-down limits of i^{th} unit in MW. Thus the constraints of (8) due to ramp rate constraints is modified as

$$max(P_{Gi\,min}, P_{Gi\,(t-1)} - DR_i) \leq P_{Git} \leq min(P_{Gi\,max}, P_{Gi\,(t-1)} + UR_i) \qquad (9)$$

Such that

$$P_{Gi\,min} = max\,(P_{Gi\,min}, P_{Gi\,(t-1)} - DR_i)$$

and

$$P_{Gi\,max,} = min\,(P_{Gi\,max}, P_{Gi\,(t-1)} + UR_i) \qquad (10)$$

3. Determination of Generation Levels

To satisfy the equality constraint of equation (4), a loading of any one unit is selected as the depending loading P_{GNT}

Assuming the power loading of (N-1) generators as specified, the power level of N^{th} generator is given by

$$P_{GNt} = P_{Dt} + P_{Lt} - \sum_{i=1}^{N-1} P_{Git} \qquad (11)$$

The transmission loss P_{Lt} is a function of all the generators including that of dependent, generator and it is given by

$$P_{Lt} = \sum_{i=1}^{(N-1)} \sum_{j=1}^{(N-1)} P_{Git} B_{ij} P_{Gjt} + 2P_{Nt} \left(\sum_{i=1}^{(N-1)} B_{Ni} P_{Gjt} \right) + B_{NN} P_{GNt}^{2} \qquad (12)$$

Expanding and rearranging equation (12) becomes

$(N-1)$ $(N-1)$ $(N-1)$ $(N-1)$

$$B_{NN}P^{2}_{GNt} = \left(2\sum_{i=1} B_{Ni}P_{Git}^{-1}\right) P_{GNt} + \left(P_{Dt} + \sum_{i=1} \sum_{j=1} P_{Git}B_{ij}P_{Gjt} - \sum_{i=1} P_{Gjt}\right) = 0 \qquad (13)$$

The loading of the dependent generator (ie, N^{th}) can be determined by solving equation (13) using standard algebraic method.

4. Particle Swarm Optimization

Particle swarm optimization is one of the most recent developments in the category of combinatorial metaheuristic optimizations. This method has been developed under the scope of artificial life where PSO is inspired by the natural phenomenon of fish schooling or bird flocking. PSO is basically based on the fact that in quest of reaching the optimum solution in a multi-dimensional space, a population of particles is created whose present coordinate determines the cost function to be minimized. After each iteration the new velocity and hence the new position of each particle is updated on the basis of a summated influence of each particle's present velocity, distance of the particle from its own best performance, achieve so far during the search process and the distance of the particle from the leading particle, i.e. the particle which at present is globally the best particle producing till now the best performance i.e. minimum of the cost function achieved so far. Let x and v denote a particle position and its corresponding velocity in a search space, respectively. Therefore, the i^{th} particle is represented as $x_i = (x_{i1}, x_{i2}, . . .,x_{id})$ in the 'd' dimensional space. The best previous position of the i^{th} particles recorded and represented as $pbest_i = (pbest_{i1}, pbest_{i2}, . . .,$

$pbest_{id})$. The index of the best particle among all the particles in the group is represented by the $gbest_d$. The rate of the velocity for the particle i is represented as $v_i=(v_{i1}, v_{i2}, . . ., v_{id})$. The modified velocity and position of each particle can be calculated using the current velocity and the distance from $pbest_{id}$ to $gbest_d$ as shown in the following formulae:

$$v_{id}^{k+1} = w * v_{id}^{k}+c_1 * rand(\,) * (pbest- x_{id}^{k})+c_2 * rand(\,) * (gbest_d-x_{id}^{k}) \qquad (14)$$

$$x_{id}^{k+1} = x_{id}^{k}+ v_{id}^{k+1} \qquad i=1,2,\ldots,N_p,\ d=1,2,\ldots\ N_g \qquad (15)$$

where, N_P is the number of particles in a group, Ng the number of members in a particle, k the pointer of iterations, w the inertia weight factor, C_1, C_2 the acceleration constant, rand( ) the uniform random value in the range [0,1], v_i^k the velocity ofa particle i at iteration k, $v_d^{min} \le v_{id}^{k} \le v_d^{max}$ and $x_i^k$is the current position of a particle i at iteration k. In the above procedures, the parameter v^{max} determined the resolution, with which regions are to be searched between the present position and the target position. If v^{max} is too high, articles might fly past good solutions. If v^{max} is too small, particles may not explore sufficiently beyond local solutions. The constants C_1 and C_2 represent the weighting of the stochastic acceleration terms that pull each particle toward the pbest and gbest positions. Low values allow particle to roam far from the target regions before being tugged back. On the other hand, high values result in abrupt movement toward or past, target regions. Hence, the acceleration constants C_1 and C_2 were often set to be 2.0 according to past experiences. Suitable selection of inertia weight 'w' provides a balance between global and local explorations, thus requiring less iteration on average to find a sufficiently optimal solution. As originally developed,' w 'often decreases linearly from about 0.3to -0.2 during a run. In general, the inertia weight w is set according to the following equation:

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{max}} \text{ x iter} \qquad (16)$$

where $iter_{max}$ is the maximum number of iterations and 'iter' is the current number of iterations.

5. Computational Algorithm

In this section, An algorithm based on particle Swarm Optimization for solving the dynamic economic load dispatch problem is described as follows :

Let

P_K = [P_{11}, P_{21}, P_{i1}, …… , P_{N1}), …. , (P_{1m}, P_{2m}, …..,P_{im}, …., P_{Nm}) ….,]

Be the trial vector designating K^{th} particle of the population and K = 1, 2, 3, …….Np. The elements of vector P_K are real power outputs of N generating units over m time sub – internals.

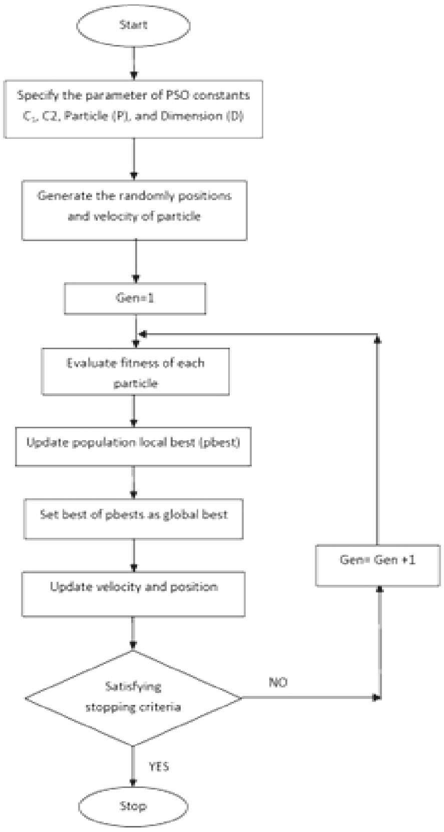

Fig1. Flow chart of PSO based DELD

Step 1

Read the System input data which consisting of fuel cost curve co–efficients, valve point loading effect co–efficient, power generation limits, ramp rate limits of all generators, load demands, transmission losses co–efficients, number of sub–intervals and duration of sub – intervals.

Step 2

Initialize the particles of the population in a random manner according to the limits of each unit including individual dimensions, search points and velocities. These initial particles must be feasible candidate solutions that satisfy the practical operating constraints.

Step 3

Calculate the cost value C_{it} (P_{Git}) for each individual P_K in the population.

Step 4

Compare the cost of each particle with that of its *P* best. If the new cost value for P_K is less than that obtained with P_{bestK}, then replace the co-ordinates of P best K with the present co-ordinates of P_K.

Step 5

Compare the cost values of $P_{best\ K}$ of all particles to determine the best particle store the co-ordinates of the best particle as *g*best.

Step 6

Modify the member velocity of each particle according to following equation.

$$V_i^{k+1} = \omega V_i^k + C_1\, rand_1\, (P\ best - S_i^k) + C_2\, rand_2\, (g\ best - S_i^k) + C_3\, rand_2\, (g\ best - S_i^k)\ a$$

$$\text{Where} \quad \omega = \omega_{max} - \left[\frac{(\omega\ max - \omega min)}{iter\ max}\right] \text{iter.}$$

and where ω_{max} is the initial weight;$\omega_{min}$is the final weight;ter_{max} is the maximum iteration number and iter is the Current iteration number.

Step 7

Modify the member current position (Searching point) of each particle according to equation following.

$$S_i^{k+1} = S_i^k + V_i^{k+1}$$

Step 8

If the number of iterations reaches the maximum, then go to step 9 other wise, go to Step 3.

Step 9

The particle that generates the latest best is the solution of the problem.

6. Simulation Results

The effectiveness of proposed methodology for solving DELD problem described above has been tasted with three different cases of power system ie., 5 – unit, 10-unit and 15-unit systems. The generating unit operational constraints, ramp rate limits, effects of valve point loadings and transmission losses are considered for the analysis. The simulations were carried out in MATLAB 7.0 platform and executed with Pentium-® Dual core, with 1GB RAM, 2.7 GHZ processor. The best solution obtained through the proposed PSO method is compared to the GA method.

6.1 Test Case – I : 5 – Unit System

The five – unit system [8 - 9] with non-smooth fuel cost function is used to demonstrate the performance of the proposed method. Table-1 gives the optimal scheduling of all units for 24 hrs by using PSO technique. Table-2 shows the total cost comparison of test case I.

Table 1. Optimal dispatches of 5-unit system

Hour	PG1	PG2	PG3	PG4	PG5	Loss	Demand	Operating Cost(in $)
1	51.2456	20.1976	42.8260	250.0000	50.0000	4.2693	410.0000	1608.5674
2	75.0000	34.3343	30.4485	250.0000	50.0000	4.7828	435.0000	1624.6876
3	10.2204	107.4335	60.0822	75.3530	227.0788	5.1680	475.0000	1753.4238
4	68.1216	102.7230	94.3703	212.7369	58.2899	6.2418	530.0000	1791.4760
5	75.0000	20.5376	118.9222	123.9758	226.1562	6.5918	558.0000	1702.4132
6	34.6159	20.0000	148.2685	185.5492	227.3140	7.7476	608.0000	2089.2800
7	75.0000	125.0000	175.0000	209.5030	50.0000	8.5030	626.0000	2048.6304
8	11.6250	97.7564	122.9043	138.2697	292.7871	9.3425	654.0000	2118.7030
9	73.2615	125.0000	62.1309	213.5632	226.6034	10.5590	690.0000	2263.2605
10	10.6492	38.5567	170.7634	226.4828	268.0817	10.5338	704.0000	2454.5191
11	75.0000	125.0000	175.0000	250.0000	106.0948	11.0948	720.0000	2624.4094
12	75.0000	125.0000	175.0000	250.0000	126.6465	11.6465	740.0000	2572.3918
13	10.0000	103.3458	175.0000	201.7246	224.3948	10.4651	704.0000	2138.9582
14	73.0505	110.5847	100.3448	131.7886	284.6033	10.3719	690.0000	2324.2674
15	75.0000	125.0000	175.0000	238.3709	50.0000	9.3709	654.0000	2273.9304
16	71.6093	87.8829	45.4087	194.3098	188.2620	7.4727	580.0000	2121.8570
17	33.6913	67.0726	164.1943	250.0000	50.0000	6.9582	558.0000	2133.7475
18	35.5721	20.0000	117.0004	213.6815	229.6621	7.9161	608.0000	1831.8840
19	11.1548	60.6435	82.4314	217.4171	291.9514	9.5983	654.0000	2309.2464
20	75.0000	84.1605	152.8852	174.1731	228.0892	10.3081	704.0000	2389.4659
21	61.0661	106.0007	33.3400	216.3120	170.9630	7.6817	580.0000	1989.5730
22	75.0000	124.3045	175.0000	40.8312	197.7896	7.9252	605.0000	2168.9264
23	75.0000	48.1128	52.2012	211.7345	146.1228	6.1713	527.0000	1852.5568
24	46.6321	61.5139	120.9766	97.6512	140.6145	4.3883	463.0000	1784.2558

Table-2. Cost comparison of test case – I

Method	Total Fuel Cost (in $)			Execution time (Sec)
	Best	Average	Worst	
GA	49970.431100	50216.588197	51803.295421	10.919153
PSO	48742.125217	50083.847087	52339.780205	27.153922

6.2 Test Case – II： 10 – Unit System

In this case 10-Units System is considered. The fuel cost data was extracted from [10].

Table 3. Optimal dispatches of 10-unit system

Hour	PG1	PG2	PG3	PG4	PG5	PG6	PG7	PG8	PG9	PG10	Demand	Operating Cost(in $)
1	150.0000	135.0000	73.0000	60.0000	111.0714	160.0000	130.0000	110.8463	51.0823	55.0000	1036.0000	29257.0078
2	150.0000	135.0000	148.6619	61.7503	224.9785	133.5153	126.9219	53.4570	20.7151	55.0000	1110.0000	30564.5051
3	150.0000	251.5097	290.8727	60.6440	234.8814	79.0015	20.2373	47.7960	68.0575	55.0000	1258.0000	35293.7646
4	442.2164	393.9755	73.3717	60.3513	82.2046	57.5606	129.3465	52.3742	59.5992	55.0000	1406.0000	37570.5471
5	150.0000	382.3080	254.0895	68.0434	243.0000	57.7546	127.8772	61.9272	80.0000	55.0000	1480.0000	39976.0102
6	184.6976	460.0000	193.7084	63.6048	243.0000	146.3531	123.1364	120.0000	38.4997	55.0000	1628.0000	43240.2360
7	470.0000	460.0000	278.8810	117.7416	74.7329	60.8635	111.6926	51.6417	21.4467	55.0000	1702.0000	44412.9854
8	470.0000	460.0000	240.9446	60.2814	191.4108	65.8463	60.3335	120.0000	52.1833	55.0000	1776.0000	46660.9988
9	470.0000	355.6690	339.3071	102.7938	220.1290	155.3364	121.5030	84.2616	20.0000	55.0000	1924.0000	49333.6494
10	470.0000	460.0000	340.0000	300.0000	211.9018	60.0438	21.4331	105.1282	48.4931	55.0000	2072.0000	53855.8456
11	470.0000	460.0000	340.0000	300.0000	243.0000	73.7575	130.0000	47.5651	26.6773	55.0000	2146.0000	54621.1532
12	470.0000	460.0000	340.0000	300.0000	243.0000	160.0000	121.1715	50.5985	20.2300	55.0000	2220.0000	56127.2586
13	470.0000	398.9729	337.6285	139.0549	243.0000	112.9429	130.0000	120.0000	65.4008	55.0000	2072.0000	52816.4954
14	470.0000	325.5662	209.2198	300.0000	212.7898	160.0000	104.0332	47.0115	40.3795	55.0000	1924.0000	49820.0759
15	470.0000	460.0000	226.4577	61.9426	151.0992	122.4275	125.9081	78.0092	25.1557	55.0000	1776.0000	45966.9215
16	464.1964	250.5439	292.7530	60.1861	77.0894	160.0000	53.3521	120.0000	20.8791	55.0000	1554.0000	41004.4132
17	470.0000	396.0921	89.1605	61.3896	182.5181	66.1216	81.8681	47.0180	30.8321	55.0000	1480.0000	39519.6345
18	455.8865	222.2870	337.0273	61.2060	220.9209	157.9364	49.3883	48.0643	20.2833	55.0000	1628.0000	42061.8211
19	446.0480	460.0000	109.6093	92.6814	224.9473	160.0000	130.0000	47.0352	50.6788	55.0000	1776.0000	45933.1362
20	470.0000	397.9957	334.8113	253.8644	229.7589	57.0000	130.0000	120.0000	23.5697	55.0000	2072.0000	52450.4058
21	470.0000	460.0000	340.0000	190.3943	73.1533	140.0321	53.7977	89.0470	52.5757	55.0000	1924.0000	49715.2608
22	470.0000	185.4293	213.5526	60.6946	243.0000	160.0000	102.1602	116.7740	21.3893	55.0000	1628.0000	43261.2280
23	150.0000	141.5200	337.0218	60.1941	180.7313	160.0000	93.2689	87.3329	66.9310	55.0000	1332.0000	36154.0133
24	150.0000	135.0000	184.0461	186.2702	107.6559	126.4927	94.1831	105.2357	40.1164	55.0000	1184.0000	33038.4371

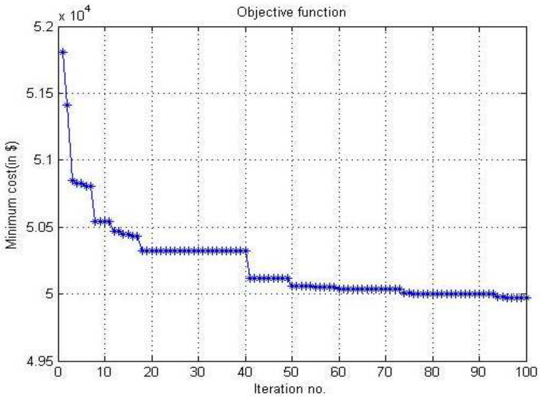

Fig 2. Convergence characteristics of PSO for test case -1

Table 4. Cost comparison of test case-II.

Method	Total Fuel Cost (in $)			Execution time (Sec)
	Best	Average	Worst	
GA	768278.300549	769292.782845	773854.756593	158.434365
PSO	767829.887398	768840.407242	773829.706121	58.252626

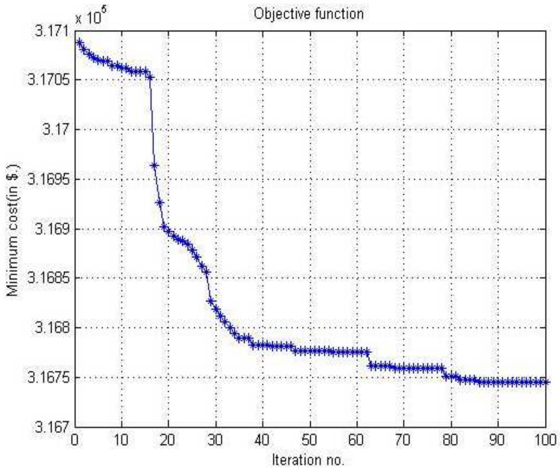

Fig 3. Convergence characteristics of PSO for test case –II

6.3 Test Case – III : 15 – Unit System

In this case (Table 5), the system contains 15 generating units whose data was extracted from [11].

Table-6 cost comparison of test case-III

Method	Total Fuel Cost (in $)			Execution time (Sec)
	Best	Average	Worst	
GA	1055681.360690	1060091.004757	1069658.552632	49.846248
PSO	1052655.804395	1055963.298853	1064633.416370	18.569127

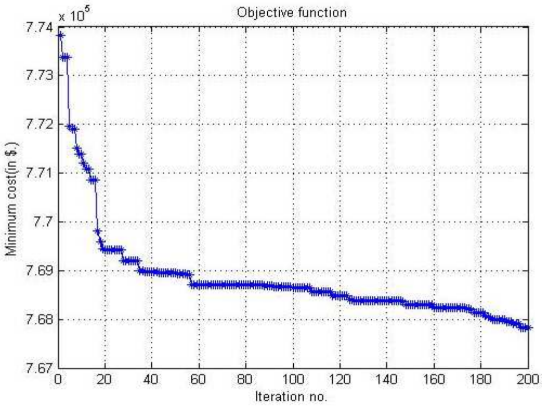

Fig 4. Convergence characteristics of PSO for test case –III

7. Analysis

In the PSO simulation study on the test case, the value of inertia weight *w* plays an important role for maintaining the balance between the global and local search. A large value of *w* facilitates a global search while a small value of *w* facilitates the local search. The process of linearly decreasing the value of *w* from a relatively large value to small value through the course of PSO run ensures better global search ability at the beginning of the run where as more local search ability near the end of run. In order to achieve best performance, the inertia weight was linearly varied from 0.9 to 0.2 with c_1 =2 and c_2=2. The value of swarm size and number of generators were considered to be 20 and up to 200 respectively.

8. Conclusion

Dynamic economic load dispatch is a complex optimization problem whose importance may increase as competition in power generation intensifies. This paper has attempted to clarify the techniques that provide feasible solution. This paper presented PSO technique to solve the DELD problem for the determination of global or near global optimum dispatch solution. The comparison of numerical results demonstrate the performance and applicability of the proposed PSO method. It is ascertained that the PSO method as computationally better convergence property as it converges with lesser number of iterations than GA.

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Table 5. Optimal dispatches of 15-unit system

Hour	PG!	PG2	PG3	PG4	PG5	PG6	PG7	PG8	PG9	PG10	PG11	PG12	PG13	PG14	PG15	Operating cost(in $)	loss	Demand
1	455.0000	455.0000	30.0000	130.0000	283.9536	136.3790	350.6896	94.4186	34.5740	25.2551	32.4264	67.3550	25.9765	26.7222	15.0000	28574.8373	25.4390	2236.0000
2	455.0000	455.0000	130.0000	130.0000	196.4887	324.5285	178.4046	123.3820	50.7207	47.5829	24.8015	52.1844	47.9794	34.8955	15.0000	28759.9535	24.6032	2240.0000
3	455.0000	455.0000	130.0000	130.0000	367.0061	141.9066	181.4186	89.3867	33.4532	36.5310	33.1911	76.4849	74.5521	35.7252	15.0000	28720.3019	27.4037	2226.0000
4	336.4218	347.4294	121.0266	25.0844	292.5248	206.4267	354.2087	300.0000	26.7085	26.8894	49.1405	32.4721	85.0000	55.0000	15.0000	29245.4128	36.0494	2236.0000
5	455.0000	455.0000	130.0000	127.0686	254.9009	357.7845	144.0694	60.0000	25.5117	66.8143	80.0000	68.8080	28.7076	55.0000	15.0000	29312.2973	24.2358	2298.0000
6	455.0000	254.4125	130.0000	43.0963	300.0415	460.0000	202.7918	61.8872	162.0000	73.2643	43.2567	80.0000	31.2576	31.7874	15.0000	29718.5487	26.4433	2316.0000
7	455.0000	455.0000	130.0000	130.0000	187.4040	382.7662	140.8093	60.6599	72.6017	122.4009	71.0829	80.0000	38.8692	15.0000	15.0000	29670.6037	24.1748	2331.0000
8	327.4358	455.0000	130.0000	81.8511	190.1175	421.6563	394.9367	103.0709	144.9321	87.2493	35.0459	35.7029	25.3293	27.5990	15.0000	30930.6674	30.5313	2443.0000
9	455.0000	455.0000	130.0000	130.0000	470.0000	443.6116	193.1029	60.6505	162.0000	28.1598	29.7135	46.1187	35.7570	17.5353	15.0000	32982.9009	40.1840	2630.0000
10	455.0000	455.0000	130.0000	130.0000	163.0573	460.0000	465.0000	147.0706	28.8900	160.0000	80.0000	32.5131	25.9364	18.7356	15.0000	33831.5805	36.4994	2728.0000
11	455.0000	455.0000	130.0000	114.8343	268.2912	460.0000	305.8594	127.6363	162.0000	139.1903	47.7472	76.3848	54.4948	15.0000	15.0000	34701.6029	41.6635	2783.0000
12	455.0000	455.0000	130.0000	130.0000	277.7861	372.7429	465.0000	61.4347	25.1051	142.5574	69.4539	80.0000	85.0000	55.0000	15.0000	34537.7375	32.4224	2785.0000
13	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	390.8762	63.9947	29.4388	74.0300	21.4934	80.0000	25.7383	20.6615	15.0000	34342.1911	39.6385	2780.0000
14	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	465.0000	80.5842	56.0827	26.0768	20.1059	61.7731	30.4742	18.1946	15.0000	34882.7400	41.4264	2830.0000
15	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	196.7564	241.5708	125.3336	160.0000	80.0000	61.2733	25.3546	28.3822	15.0000	36942.7699	61.8353	2970.0000
16	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	465.0000	122.0004	25.1743	98.4848	80.0000	39.9064	33.5414	17.9158	15.0000	36227.3946	45.1178	2950.0000
17	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	463.8575	62.0837	77.4813	45.2790	80.0000	29.1009	39.3170	33.9680	15.0000	35713.2565	42.4449	2902.0000
18	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	357.0486	61.0677	108.3192	52.6463	21.1558	57.2787	58.4528	15.0000	15.0000	34743.7888	41.3179	2803.0000
19	455.0000	455.0000	130.0000	130.0000	470.0000	460.0000	307.1463	60.0000	27.3575	29.3268	22.4734	80.0000	27.5190	21.5531	15.0000	32992.5413	37.7957	2651.0000
20	370.2538	258.2713	130.0000	21.1824	414.1133	460.0000	465.0000	97.9128	29.1347	158.7492	80.0000	21.9829	69.3840	30.7144	15.0000	32630.6135	36.2391	2584.0000
21	455.0000	433.5242	93.9466	130.0000	157.8839	460.0000	299.0259	162.8953	29.2621	26.2041	80.0000	43.8298	34.0061	39.5330	15.0000	30753.9952	26.7565	2432.0000
22	455.0000	455.0000	130.0000	130.0000	216.4957	341.8440	275.3086	65.0980	84.7162	28.3002	72.2439	20.4062	27.8519	19.9681	15.0000	29360.2907	23.8149	2312.0000
23	274.2489	150.8999	130.0000	130.0000	464.3938	237.6305	410.5658	60.4536	107.4239	106.8781	78.7423	71.2340	29.1906	29.7263	15.0000	29055.4999	34.0890	2261.0000
24	455.0000	224.6691	127.7122	102.4704	157.8257	135.2480	442.4469	135.4376	162.0000	28.3150	80.0000	80.0000	83.1537	55.0000	15.0000	29198.3614	28.9226	2254.0000

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