Application of Cauchy Mutated Memetic Particle Swarm Optimization Algorithm to Economic Dispatch Problem with Practical Constraints

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Abstract— This paper presents a new solution approach to economic dispatch (ED) problems with practical operating constraints using a Cauchy mutated memetic particle swarm optimization (CMMPSO) algorithm. The practical operating constraints such as valve point effect, multiple fuel options, prohibited operating zones, ramp rates of generators and environmental constraints are considered in this paper. ED problems have non-smooth cost functions with equality and inequality constraints that make the problem of finding the global optimum difficult using any traditional optimization approaches. The main objective of this paper is to develop a simple, reliable and efficient algorithm for solving the Economic Dispatch problem with multiple practical operating constraints. The proposed CMMPSO algorithm is used to test ED problems with different practical operating constraints. The results of the CMMPSO are compared with the results of Particle Swarm Optimization (PSO) and differential evolutionary algorithm.

Keywords — Economic Dispatch, Cauchy Mutated Memetic Particle Swarm Optimization, Multi Fuel, Prohibited Zones, Ramp Rate, Valve Point Effect.

1 Introduction

The main objective of economic power dispatch problem is to determine the optimal combination of power outputs for all generating units, which minimizes the total fuel cost of thermal power plants while satisfying load demand and operating constraints of a power system. This makes the ED problem a large-scale non-linear constrained optimization problem. Conventional techniques offer good results but when the search space is non-linear and it has discontinuities they become very complicated with a slow convergence ratio and not always seeking to the optimal solution. New numerical methods are needed to cope with these difficulties, especially those with high-speed search to the optimal and not being trapped in local minima.

The ED problem with of non linear cost function is discussed in [1] by G.L.Vivani. The stochastic search algorithms such as genetic algorithm (GA) [2], evolutionary programming (EP) [3], simulated annealing (SA) [4] and particle swarm optimization (PSO)[5]. SA is applied in many power system problems. But, the setting of control parameters of the SA algorithm is a difficult task and convergence speed is slow when applied to a real system [6]. The Tabu Search (TS) method have been applied solve to the ED problem [7]. Although these heuristic methods do not always guarantee discovering the globally optimal solution in finite time, they often provide a fast and reasonable solution (suboptimal nearly global optimal).Though the GA methods have been employed successfully to solve complex optimization problems, recent research has identified some deficiencies in GA performance. This degradation in efficiency is apparent in applications with highly epistemic objective functions. Moreover the premature convergence of GA degrades its performance and reduces its search capability that leads to a higher probability toward obtaining a local optimum. Some modification has been introduced to make GA to explore better solution space [8]. EP seems to be good method to solve optimization problems. When applied to problems consisting of more number of local optima the solutions obtained from EP method is just near global optimum one. In addition EP takes long simulation time in order to obtain solution for such problems. EP with Changes in mutation process was presented by Sinha [9], to solve the economic dispatch problem.

Hybrid methods combining two or more optimization methods were introduced [10]-[12]. The generation cost function for fossil fired plants can be represented as a segmented piecewise quadratic function. The generating units, particularly those that are supplied with multi-fuel sources (coal, nature gas, or oil), lead to the problem of determining the most economic fuel to burn. J.H.Park et al. [13] proposed to apply a Hopfield Neural Network (HNN) to PED problem for a piecewise quadratic cost function. Lee at al. [14] presented an improved Adaptive Hopfield Neural Network (AHNN) approach for finding solution of ED with multiple fuel options. It is well known that HNN converges very slowly and normally takes large number of iterations. Differential Evolutionary (DE) algorithm [15], may prove to be very effective in solving nonlinear ED problems with out any restriction on the shape of the cost curves [16].PSO is one of the modern heuristic algorithms developed by Kennedy and Eberhart [17]-[19]. It has been developed through simulation of simplified social models. Compared to other evolutionary methods, the advantages of PSO are ease of implementation and only few parameters to adjust. PSO is applied to solve ED problem with various constraints [20] – [25]. K.E.Parsopoulos proposes a modified PSO is called as

Memetic Particle Swarm Optimization (MPSO), which combine both PSO and local search method to get near global solution. MPSO consists of two main components: a global one that is responsible for the global search of the search space, and a local one, which performs more refined search around potential solutions of the problem. As sequential quadratic programming (SQP) is an effective deterministic optimization technique [20], in this paper SQP is used as the local search step in the MPSO algorithm. Updating velocity equation by using the Gaussian and Cauchy probability distributions of the PSO is very effective in solving economic dispatch problems. Thus in the MPSO algorithm, Cauchy mutation (CM) is incorporated with a view to enhancing diversified search and increasing the rate of convergence. The proposed algorithm is termed as Cauchy mutated memetic particle swarm optimization (CMMPSO) .

The proposed CMMPSO algorithm is used to solve ED problem considering various practical constraints. The CMMPSO algorithm has been successfully tested on various sample test systems of ED problems. The comparison of results from the previously methods shows the proposed method provides global optimal or near global optimal solutions for realistic ED problems with reasonable execution time.

The rest of the paper is organized as follows: Section II describes formulation of problem statement of ED problem. Section III explains the CMMPSO algorithm for solving the ED problems. Simulation results are presented and compared with those of other algorithms in section IV. Lastly, section V outlines the conclusions

2. Formulation of ED Problem

The ED problem is to schedule the outputs of the online generating units so that the total fuel cost of generation can be minimized while simultaneously satisfying all unit and system equality and inequality constraints. The objective function can be formulated as

$$\text{Minimize } F_T = \sum_{i=1}^{N} F_i(P_i) \quad (1)$$

Where $F_i(P_i)$ is the fuel cost function of ith generator (in $/hr), P_i is the power output of ith unit, n is the number of generating units in the system. The quadratic fuel cost function of the ith generator is defined by,

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i \quad (2)$$

Where, a_i, b_i and c_i are the cost coefficients of generator i.

While minimizing the total generation cost, the equality and inequality constraints of the system should not be violated. The set of constraints are given below,

$$\sum_{i=1}^{N} P_i = P_{load} + P_{loss} \quad (3)$$

Where, P_{load} the total system is demand in MW and P_{loss} is the total transmission losses in the system

$$P_{i\min} \le P_i \le P_{i\max} \quad (4)$$

Where, $P_i^{\min}$ and $P_i^{\max}$ are the minimum and maximum power outputs of the ith unit in MW.

In practical, the objective function of ED problem has non differential points according to valve-point loadings and multiple fuels. Therefore, the objective function should be composed of a set of non-smooth cost functions.

The cost function is not a continuous function in case of prohibited operating zones. The ED problem becomes a multi objective optimization problem while considering the environmental constraints.

In this paper, four cases of cost functions are considered. First is the case with the valve-point loading problem where the objective function is generally described as the superposition of sinusoidal functions and quadratic functions. Second is the case with the multiple fuels problem where the objective function is expressed as the piecewise quadratic cost function. Third is the case with prohibited operating zone problem, where the objective function is expressed as the discontinuous cost function. The other is the case with environmental constraints, where the problem is multi objective. So along with minimization of total system cost, the emission of NO_2 and SO_2 has to be minimized simultaneously.

A. ED Problem with valve point constraints

In the case with the valve point loading problem, where the objective function is non-linear and non-convex. The generator with multi valve steam turbines has very different input-output curve compared with the smooth cost function. The valve point results in as each steam valve starts to open, the ripples like in Fig.1.

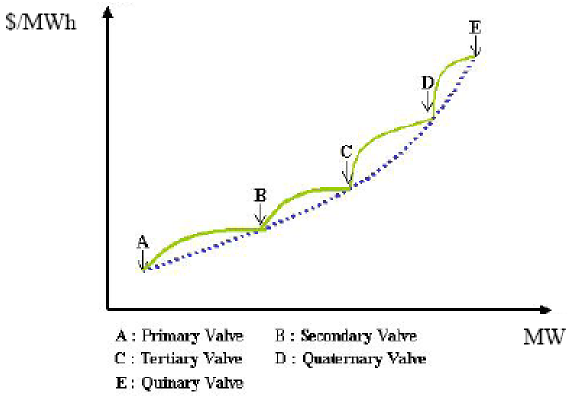

Figure 1. Fuel Cost functions for a thermal generation unit with three admission valves

To take account for the valve point effects, sinusoidal functions are added to the quadratic cost functions as follows:

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i + \left| e_i \sin(f_i (P_i^{\min} - P_i)) \right| \quad (5)$$

Where, e_i and f_i are the fuel cost coefficients of generator i, reflecting valve point effects.

B. ED Problem with Multiple Fuel Options

A piecewise quadratic function is used to represent the input-output curve of a generator with multiple fuel option. A generator with *k* fuel options the cost curve is divided into *k* discrete regions between lower and upper bounds.

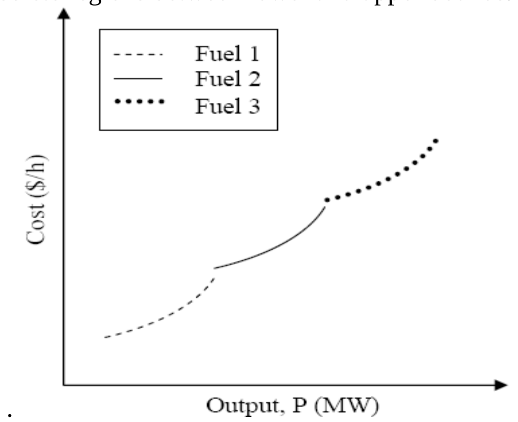

Figure 2. Fuel cost function of a thermal generation unit with multiple fuels

The economic dispatch problem with piecewise quadratic function is defined as

$$F_i(P_i) = \begin{cases} a_{i1}P_i^{\ 2} + b_{i1}P_i + c_{i1},\ fuel1, P_i^{\min} \le P_i \le P_{i1} \\ a_{i2}P_i^{\ 2} + b_{i2}P_i + c_{i2},\ fuel2, P_{i1} \le P_i \le P_{i2} \\ . \\ . \\ a_{ik}P_i^{\ 2} + b_{ik}P_i + c_{ik},\ fuelk, P_{ik-1} \le P_i \le P_i^{\max} \end{cases} \tag{6}$$

Where, $F_i(P_i)$ is the fuel cost function of i^{th} unit, P_i is the power output of i^{th} unit, and a_{ik}, b_{ik} and c_{ik} are cost coefficients of the i^{th} unit using the fuel type *k*.

C. ED Problem with Prohibited Operating Zones

The basic economic dispatch with prohibited zones minimizes the system cost (1) based on smooth quadratic cost functions (2). This cost function present regions were operation is not allowed and this region can be modeled as in equality constraints (7). The dispatch considers both power balance constrain and the generation limit constraint.

$$P_{Gi} \in \begin{cases} P_{Gi}^{\ \min} \le P_{Gi} \le \overline{P_{Gi}^{1}} \\ P_{Gi}^{K-1} \le P_{Gi} \le P_{Gi}^{K} \quad , K = 2, \ldots. n_z \\ P_{Gi}^{n_Z} \le P_{Gi} \le P_{Gi}^{\max} \end{cases} \tag{7}$$

Where, P_{Gi}^{k-1} and P_{Gi}^{k} are the lower and upper bound of the k^{th} prohibited zone of unit i and n_Z is the number of prohibited zone of unit i.

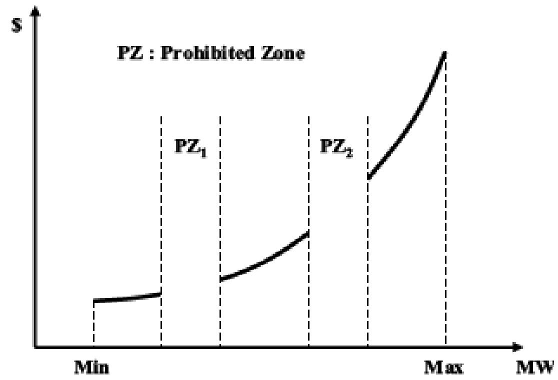

Figure 3. Fuel cost function with two prohibited operating zones.

D. ED Problem with Environmental Constraints

Environmental economic dispatch determines the power allocation that reduces system cost considering the level of emissions produced. These emissions must be modeled through functions that relate emissions with power production for each unit. Sulfur dioxide emission depends on the fuel consumption and they take the same shape of the fuel cost function. NO_2 emissions are more difficult to predict, because they come from different sources. The curve for combined NO_2 and SO_2 emission is as shown in Fig 4.

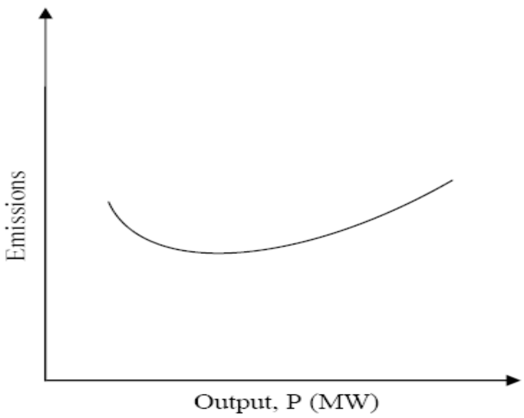

Figure 4. Combined NOx and SO2 function

Fuel cost objective,

$$C = \sum_{i=1}^{n} \left(a_i P_i^2 + b_i P_i + c_i \right) \tag{8}$$

SO_2 Emission objective,

$$E_{SO_2}(P_{Gi}) = \sum_{i=1}^{n} \left(a_{iS} P_{Gi}^2 + b_{iS} P_{Gi} + c_{iS} \right) \tag{9}$$

NO_2 Emission objective,

$$E_{NO_2}(P_{Gi}) = \alpha_i + \beta_i P_{Gi} + \gamma_i P_{Gi}^{\ 2} + \mu_i \exp(\lambda_i P_{Gi}) \tag{10}$$

Where, $\alpha_i, \beta_i, \gamma_i$ and λ_i are the emission coefficient of unit i.

The multi objective of the economical / environmental power dispatch is to minimize simultaneously the cost function and the emission function,

$$\text{Minimize}\left[\sum_{i=1}^{n_g} F_i(P_{Gi}), \sum_{i=1}^{n_g} E_{NO_x}(P_{Gi}), \sum_{i=1}^{n_g} E_{SO_2}(P_{Gi})\right] \quad (11)$$

3. Cauchy Mutated Memetic Particle Swarm Optimization Based ED

The control variables of the ED problem is the real power output of the Generators. The process of implementing the CMMPSO is as follows:

1) Initialization of particles: Generate randomly the real power output of generators within the feasible range for all the *n* particles. .

$$X_k^i = \lfloor P_{g1}, P_{g2}, \ldots P_{n_g} \rfloor \quad (12)$$

Where, n_g is the total number of generating units. Check is there any violations in individual generator power limits and the energy balance equation. Set the iteration count *iter* = 1.

2) The fitness evaluation of each particle: Each particle is evaluated using the fitness function of the problem to minimize the total fuel cost of the system. In this paper ED problem is solved with four different constraints. The constraints are added to the objective function as a penalty function. These values are chosen such that if there is any constraint violations the fitness value corresponding to that particle will be ineffective.

$$F_i = \sum_{i=1}^{n_g} F_i(P_{gi}) + \sum_{i=1}^{n_g} \mu_1 (P_{gi} - P_{gi,\lim it}) \quad (13)$$

Where, μ_1, is the penalty parameter, and

$$P_{gi,\lim it} = \begin{cases} P_{gi,\min}, if\ P_{gi} < P_{gi,\min} \\ P_{gi,\max}, if\ P_{gi} > P_{gi,\max} \\ P_{gi}, otherwise \end{cases} \quad (14)$$

In the same way the fitness function is formulated for all the four problems considered in this paper. Search for the best value of all the fitness function values $F_{i,best}$ from F_i, $i = 1,2.....M$. where M is the no of agents. Set the agent associated with $F_{i,best}$ as the global best (G_{best}) of all the agents. The best fitness value of each agent up to the current iteration is set to that if the local best of that agent $(P_{L,best})$.

The maximum fitness function value among the particles is stored as f_{max}.

3) Determination of pbest and gbest particles: Compare the evaluated fitness value of each particle with its pbest. If current value is better than pbest, then set the current location as the pbest location. If the best pbest is better than gbest, the value is set to gbest.

4) Modification of member velocity: change the member velocity of the each individual particle v_k, according to the following equations.

$$v_k^{i\ \text{iter}+1} = \chi[\omega * V_k^{i\ \text{iter}} + C_1 * rand_1(p_{best\,j}^{\ i} - x_k^{i\ \text{iter}}) + C_2 * rand_2(g_{best} - x_k^{i\ \text{iter}})] \quad (15)$$

where, k is the number of generator units, C_1 and C_2 are the cognitive and social parameters. χ, is the constriction factor used to avoid the unlimited growth of the particles velocity.

$$\chi = \frac{2}{2 - c - \sqrt{c^2 - 4c}} \quad \text{Where, } c = C_1 + C_2 \ \ and\ c > 4 \quad (16)$$

PSO also has a well-balanced mechanism with flexibility to enhance and adapt to both global and local exploration abilities. This is realized by using an inertia weight 'ω'. The dynamic change of inertia weight is represented by using the following equation,

$$\omega = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{iter_{\max}} * iter \quad (17)$$

where, $\omega_{max}/\omega_{min}$ is the initial/final weight and $iter_{max}$ is the maximum iteration count.

5) Modification of member position: The member position in each particle is modified using the following equation,

$$x_k^{i\ \text{iter}+1} = x_k^{i\ \text{iter}} + v_k^{i\ \text{iter}+1} \quad (18)$$

The mutation probability and the mutation of the some of the selected points around the best point are calculated by using the following equations,

$$P_m = \frac{R_m}{m} \quad (19)$$

$$x_k^{i\ \text{iter}+1} = x_k^{i\ \text{iter}} + f(x_k^{i\ \text{iter}}) V_k^{i\ \text{iter}} \delta_k \quad (20)$$

where, R_m and 'm' are mutation rate and the number of particles respectively and δ_j is a Cauchy random number. The value of R_m is set to 1 at the first iteration and linearly decreases to 0 at the final iteration. A uniformly distributed random number ($rand_i$) between 0 and 1 for each iteration is generated and compared with P_m. If $P_m > rand_i$ then the particle is mutated. Apply local search algorithm whenever there is a change in gbest value.

6) Termination Criteria: Repeat from 2) until the tolerance value is reached or maximum value of iteration is reached.

4. Numerical Results and Discussion

Selecting the optimal range of inertia weigh ω and acceleration factors C_1 and C_2 considerably affects the performance of the PSO algorithm. Therefore, to fix an optimal range of inertia weight, to solve the two proposed strategies, experiments were conducted using the proposed method by varying the value agent size, cognitive parameter (C_1), social parameter (C_2), starting value of the inertia weight $(\omega_{\max})$, final value(ω_{scale}) of ω in percentage of $\omega_{\max}$ $\omega_{iterscale}$ percentage of iterations, for which $\omega_{\max}$ is reduced and maximum value of step size ($V_{\max}$).

The inertia weight varied from 2.0 to 0.1, in steps of 0.1, the agent's size is varied from 10 to 1000 in steps of 10, and the maximum number of iteration is varied from 10 to 250 in steps of 10. Different possibilities of trial runs were conducted to optimally estimate all the parameters for the proposed MPSO method.

To ensure reliability in producing quality solutions by the proposed method, the relative frequency of convergence toward a quality solution is targeted. This hybrid method has reliably produced the quality solutions for inertia weights above 0.6 for all of the cases. We are using DFP (Daviden Fletcher Powel) method for local search. It will take lesser time because it will take lesser time to compute the Hessian matrix.

The optimal values for C_1 and C_2 are selected by conducting similar experiments for all the four cases considered in this paper.

There are four test systems taken to demonstrate the feasibility of the proposed method. MATLAB is used as a front end language and the Simulations are carried out on a Pentium IV, 1-GHz, 512–MB RAM processor. The solutions Obtained through the CMMPSO are compared with results reported in the literature.

A. ED Problem with Smooth Cost Function

The proposed algorithm is applied to a simple sample system consisting of three generating units [25]. In this problem the main objective is to minimize the total fuel cost subjected to power balance and generators boundary limits. The expected power demand to be supplied by all the thirteen generating units is 150 MW. The result of the proposed method is compared with traditional λ - iteration method and its tabulated in Table 1.

TABLE I. COMPARATIVE RESULT OF THE 3 BUS SYSTEMS FOR THE ED PROBLEM WITH SMOOTH COST FUNCTIONS

Parameters	λ - iteration	CMMPSO
PG1	35.09 MW	26.81 MW
PG2	64.13 MW	69.82 MW
PG3	52.47 MW	55.18 MW
Loss	1.70MW	1.71MW
Total Generation Cost	1592.65$/hr	1591.60$/hr

B. ED Problem with Valve Point Effects

The proposed algorithm is applied to a sample system, consisting of forty generating units with valve-point effects [25]. The results are compared with PSO-SQP based method reported in [21]. The CMMPSO simulation parameters chosen for this sample system are population size = 150; maximum number of generations = 300; the social and cognitive parameters are selected as 1.8.

TABLE II. COMPARATIVE RESULT OF THE 40 BUS SYSTEMS FOR THE ED PROBLEM WITH VALVE POINT CONSTRAINTS

Gen. No.	CMMPSO	PSO-SQP
1	76.3663	71.1363
2	110.816	106.5789
3	120.000	124.0000
4	80.0000	78.0000
5	88.3696	84.3806
6	140.000	145.0000
7	299.930	304.1683
8	284.637	282.505
9	284.911	287.0433
10	279.420	282.4200
11	243.681	240.138
12	225.035	228.5767
13	214.836	220.9586
14	125.000	127.0000
15	394.299	390.2998
16	394.282	385.7393
17	500.000	505.2000
18	489.261	489.2612
19	511.279	521.4016
20	550.000	545.0000
21	533.364	531.1422
22	548.599	546.5990
23	523.412	525.6342
24	523.393	514.4064
25	523.303	532.2895
26	527.558	525.4581
27	10.0563	13.0563
28	11.8758	15.8758
29	10.0000	12.0000
30	94.5326	99.5326
31	159.783	152.7833
32	189.998	186.9980
33	189.672	187.6720
34	164.981	158.8578
35	131.313	135.2112
36	179.480	181.4801
37	110.000	99.877
38	25.0000	33.543
39	90.1120	93.1120
40	550.000	547.0000

Generation cost using CMMPSO is 124540$/hr but with using PSO embedded EP the generation cost is equal to 126810$/hr [12]. For comparison, we are also simulating the PSO-SQP based ED with valve point constraints and the generation cost is 124555 $/hr for the 40 generator system, the best power output that the results from the proposed CMMPSO and its comparison with PSO-SQP method is given in Table 2. The convergence characteristic is shown in Fig. 5.

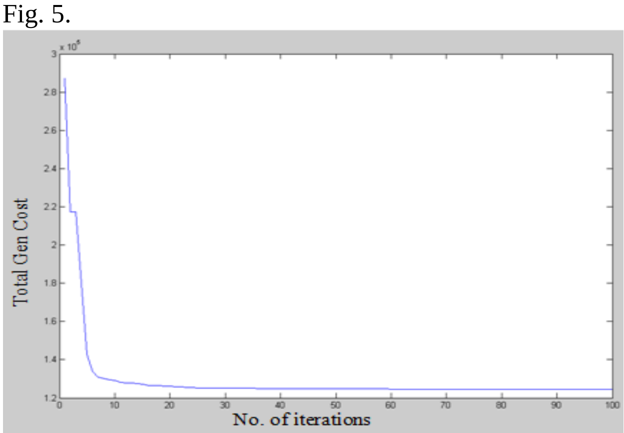

Figure 5. Convergence plot of ED problem with valve point constraints using MPSO for the forty bus test system

C. ED Problem with Multiple Fuel Options

The ten-generator system, each unit with two or three fuel options is taken to illustrate the MPSO solution to the ED problem including multiple fuel options. There are three different types of fuels: type 1, 2, and 3. the total system demand is 2700 MW. This economic dispatch problem includes one objective function with ten variable parameters (*P1, P2… P10)*, one equality and twenty inequality constraints i.e. Power balance constraint, maximum and minimum limits of each generating unit. The system data and related constraints are taken from ref. [25]. The initial population of the CMMPSO contains random choice of generation between minimum and maximum generation limits of each unit. The following control parameter has been chosen after the number of trials: N_P = 50, N_G = 150, and the value of social and cognitive parameter is 1.7.Table 3 shows the power generation from each generator for various loads with the total generation cost. The comparison of total generation cost for various loads are compared with results given in reference [20] to [26].

TABLE III. RESULT OF THE 40 BUS SYSTEM FOR THE ED PROBLEM WITH MULTIPLE FUEL OPTIONS

Gen.No	Total Demand in MW			
	2700	**2600**	**2500**	**2400**
1	232.78	200.711	191.69	207.00
2	209.13	117.351	177.83	177.83
3	425.92	379.53	223.76	223.76
4	164.78	211.928	179.08	179.08
5	380.78	453.47	362.78	362.78
6	187.78	232.23	239.85	239.85
7	285.78	300.55	292.60	292.60
8	250.78	195.191	141.76	141.76
9	232.78	218.512	342.14	342.14
10	329.45	290.511	233.15	233.15

The convergence plot for case 3 is shown in Figure 6.

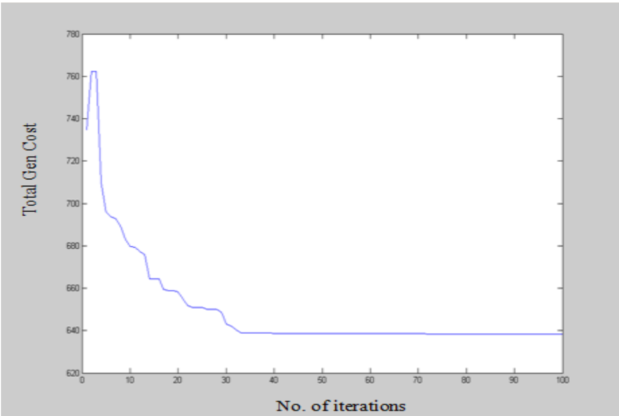

Figure 6. Convergence plot of ED problem with multiple fuel options for the 40 bus problem with 2700MW load using MPSO

II. COMPARATIVE RESULT OF THE 40 BUS SYSTEMS FOR THE ED PROBLEM WITH MULTIPLE FUEL OPTIONS

Demand in MW	Generation cost \$/hr using MPSO	Generation cost \$/hr using DE
2700	638.31	623.92
2600	578.25	574.54
2500	525.82	526.32
2400	490.16	481.86

A. ED Problem with Multiple Prohibited Operating Zones

MPSO is capable of solving ED problem featuring prohibited zones. These types of problems are extremely difficult to solve due to the large discontinuities in the feasible region. The cost coefficients, Generator limits, loss coefficients and prohibited operating zone details for the 15 generator system is taken from ref [26]. The result obtained by using MPSO is tabulated in table 5.

TABLE IV. RESULT OF THE 15 BUS SYSTEMS FOR THE ED PROBLEM WITH PROHIBITED OPERATING ZONES

Gen. No.	Real Power Output in MW	Gen. No.	Real Power Output in MW	Gen. No.	Real Power Output in MW
1	392.449	6	318.765	11	80.0000
2	355.406	7	270.427	12	20.8660
3	104.686	8	300.000	13	79.5733
4	39.6000	9	25.0000	14	29.5345
5	470.000	10	117.251	15	46.4397

B. ED Problem with Environmental Constraints

Emissions constrained Economic Dispatch problem is a multi objective problem. In this paper minimization of SO_2 is considered as a one of the objective function along with main objective, i.e. minimization of total fuel cost function. The sample test system is taken from the ref [27]. The cost function and the emission constraint for the 3 bus system is given below,

$$F_1 = 0.03546P_1^2 + 38.30553P_1 + 1243.53110$$
$$F_2 = 0.02111P_2^2 + 36.32782P_2 + 1658.56960$$
$$F_3 = 0.01799P_3^2 + 38.27041P_3 + 1356.65920$$

SO_2 Emission equations in Kg / hr are,

$$E_1 = 0.00683P_1^2 - 0.54551P_1 + 40.26690$$
$$E_2 = 0.00461P_2^2 - 0.51160P_2 + 42.89553$$
$$E_3 = 0.00461P_3^2 - 0.51160P_3 + 42.89553$$

Emission constraints in MW are,

$$35 \le P_1 \le 210$$
$$130 \le P_2 \le 325$$
$$125 \le P_3 \le 315$$

The loss coefficient matrix is,

$$B_{mn} = \begin{matrix} 0000071. & 0.000030 & 0.000025 \\ 0.000030 & 0.000069 & 0.000032 \\ 0.000025 & 0.000032 & 0.000080 \end{matrix}$$

The result of this problem by using the proposed MPSO for various loading condition is as shown in table.6.

TABLE V. RESULT OF THE 3 BUS SYSTEMS FOR THE ED PROBLEM WITH ENVIRONMENTAL CONSTRAITS

Gen.No	Total Demand in MW		
	400	**500**	**700**
1	85.6951	109.948	159.482
2	171.0892	209.069	286.184
3	150.7511	192.851	278.02
Loss	7.535	11.86	23.688
Total Gen Cost	21017.652	25782.381	36083.710

The same problem is solved by using DE and the results for the three loads 400,500 and 700 are 21016.252, 25782.182 and 36082.86 respectively. MPSO results are quite promising for the multi objective problem. In some cases the solution ends up with local optima due to multi objective nature of the problem values obtained by MPSO are comparable with other stochastic methods. We are also considering the emission of SO_2 also and the results are presented for the load of 500MW in table 7. The total cost is 39436.34 $/hr and the convergence plot is shown in fig 7.

TABLE VI. EMISSION RESULTS FOR THE LOAD OF 500 MW

Power Generation/ Losses (MW)	**Emission (Kg / hr)**
1	83.335
2	115.33
3	112.46
Loss	11.69
Emission	311.15 kg/hr

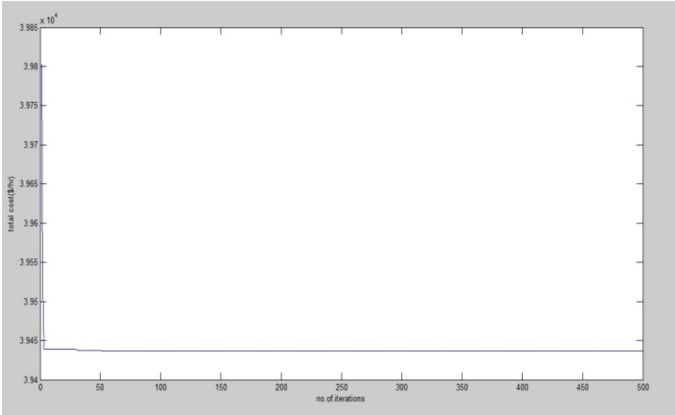

Figure 7. Convergence plot of ED problem with Emission for the 500 MW load using MPSO

5. Conclusion

The proposed MPSO method is simple, reliable and gives reasonable solution with in the reasonable computation time. The MPSO with constriction factor explores the solution space to obtain near global solution. The application of scaling factor for inertia constant ensures the convergence of the solution. DFP is used to fine tune the solution obtained from MPSO. The proposed algorithm is tested with five different test cases and the results are tabulated. Adding practical constraints to the ED problem made it more non linear. In this paper we are also considering multi objective emission dispatch problem. The time of using the local search method is critical to explore solution space to obtain the global optima. In this paper the best solution of the particular iteration along with some randomly positions are selected to apply the local search algorithm. The results obtained by the proposed algorithm are also compared with other stochastic algorithm reported in literature.

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