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Weighting Sum Method to Solve Combined Economic Emission Dispatch Problem

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***Abstract* - This paper uses Lambda iteration method and Particle Swarm optimization (PSO) method to solve Combined Economic Emission Dispatch (CEED) problem. The CEED problem is formulated by combining the fuel cost function and emission function with the help of weighting factor. Various combinations of weighting factors are used to find the optimal values of power generated by each generator in CEED problem in the given three generator set. The fuel cost is calculated with the help of Lambda Iteration method and Particle Swarm Optimization (PSO). The results from the two methods are compared. Based on the values of total fuel cost, the best combination of weighting factors is figured out.**

Keywords—Combined Economic emission dispatch, Lambda iteration method, Particle Swarm Optimization, weighting factor.

I. INTRODUCTION

Modern economy is dependent on electricity. With the increase in demand, the power generation from natural resources has also increased. The increased power generation has resulted in large source expenses. Along with increased fuel cost, the large scale energy production at thermal generating stations, huge amount of harmful gases are released into the surroundings. Apart from polluting the environment, such emissions have an adverse effect on the fuel cost. Hence the economic operation of the system is to optimize the generation cost while satisfying the prescribed load and losses that is termed as economic dispatch. The reduction of the emissions is termed as emission dispatch. While reducing the emissions, the fuel cost may be increased or while fuel cost is reduced, emissions get increased. Since fuel cost and emissions are of conflicting nature, they cannot be optimized simultaneously, hence, they are combined with the help of weighting factor and the problem is named as Combined Economic Emission Dispatch (CEED). Various techniques have been used to optimize the CEED problem [1-3].

CEED problem is a need based problem in power systems. Different techniques have been reported in the literature pertaining to environmental/economic dispatch problem. Senthil *et al.* presented an improved Tabu search algorithm of three generator system, six generator system with emission constraints and thirteen generator system with valve point effect loading [4]. M. A. Abido presented a multi-objective evolutionary algorithm for Environmental/Economic power dispatch problem, which is a non linear constrained multi-objective optimization problem; a Strength Pareto Evolutionary Algorithm (SPEA) was used to solve the formed multi-objective problem [5]. In another attempt, Abido presented a Multi-Objective Particle Swarm Optimization (MOPSO) technique for environmental/economic dispatch problem [6]. Thakur *et al.* used PSO algorithm to solve the problem of Combined Economic and Emission Dispatch with use of penalty factors [7]. Valle *et al.* provided a detailed literature on Particle Swarm Optimization, its concepts, variants and application in the field of Power Systems, in which they have performed a vast study on this optimization technique [8].

In this paper, two optimization techniques, Lambda Iteration method and Particle Swarm Optimization (PSO) have been used to solve CEED problem on a three generator set. The best combination of weighting factor was determined by comparing the respective values of fuel cost. The power output of each generator is calculated from the Combined Economic Emission function by using various combinations of weighting factors. These values of power output helps in calculating the fuel cost of each generator. The fuel cost is compared for each of the two optimization techniques, and the best valve of weighting factors is decided.

II. PROBLEM FORMULATION

Economic dispatch focuses on minimizing of fuel cost, while emission dispatch focuses on reducing the emissions caused by burning of fuel. Both the dispatch problems can be added together to form a Combined Economic Emission Dispatch (CEED) problem. The aim of CEED is to operate generators that produce electrical power in a thermal power plant with optimized levels of fuel cost and emissions, while satisfying the load demand and operational constraints. In the solution of the CEED problem, the objective is to minimize fuel cost and emission, while satisfying equality and inequality constraints.

The CEED problem is obtained here by combining the fuel cost function and the emissions function using weighting factor combined into a single objective function. The CEED equation formed is optimized by using conventional Lambda Iteration method and PSO algorithm. Various combinations of weighting factors were tested to find the best combination for which the fuel cost is reduced.

A. Combined Economic Emission Dispatch

The economic load dispatch problem can be described as an optimization (minimization) problem with the following objective function [9]

$$Min \sum_{i=1}^{n} F_i(P_i) \quad (1)$$

The fuel cost function without valve-point loading of the generating unit is given by:

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

Where, $F_i(P_i)$ is the total fuel cost function, P_i is the real power generated and a_i, b_i, c_i are the fuel cost coefficients for the i^{th} generating unit.

The emission of the thermal power plant can be formulated as a second order polynomial function as:

$$E_i(P_i) = \alpha_i P_i^2 + \beta_i P_i + \gamma_i \quad kg/hr \quad (3)$$

Where, $E_i(P_i)$ is the emission of the i^{th} unit, α_i, β_i, γ_i are the emission coefficients for the i^{th} generating unit.

Combining equations 2 and 3 into a multi objective problem, the formulated CEED problem is as :

$$C_T = \sum_{i=1}^{n} [\, w_1\{F_i(P_i)\} + w_2\{E_i(P_i)\}\,] \quad (4)$$

Where, w_1 and w_2 are the weighting factors.

The CEED problem mentioned in equation (4) has to be solved subject to the generation capacity constraint as stated in equation (5) and the total real power generation constraint stated in equation (6).

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \quad (5)$$

$$\sum_{i}^{n} P_{gi} = P_D + P_{loss} \quad (6)$$

Where, P_{gi}^{min} is the minimum real power generation limit and P_{gi}^{max} is the maximum real power generation limit of i^{th} unit. P_{gi} is the total real power generation, P_D is the total demand, and, P_{loss} is the loss in the system.

B. Lambda Iteration method

Lambda iteration method is a conventional technique used to optimize a given function. The flow chart of the Lambda iteration method is given in Fig. 1.

The objective function in this case, is described by equation (4). The optimization problem is to find the optimal power generated P_i produced by the generators in such a way that the criterion (5) is minimized and the constraints (5), (6) are satisfied. The problem has to be solved for different combinations of weighting factors. The problem is solved using Langrange's method by introducing Langrange's variable λ and formulation of a Langrange's function [9]:

$$L = C_T + \lambda\, (P_D - \sum P_i) \quad (7)$$

$$L = \sum_{i=1}^{n} [\, w_1\{F_i(P_i)\} + w_2\{E_i(P_i)\}\,] + \lambda\, (P_D - \sum P_i) \quad (8)$$

Differentiating partially with respect to P_i :

$$\frac{dL}{dP_i} - \lambda = 0 \quad (9)$$

From here, P_i can be calculated in terms of λ. Then from power balance equation λ and eventually P_i can be calculated.

C. Particle Swarm Optimization

A summary on the application of PSO to economic dispatch problem indicates that the PSO based application out performs most of the heuristic and mathematical algorithms [10].

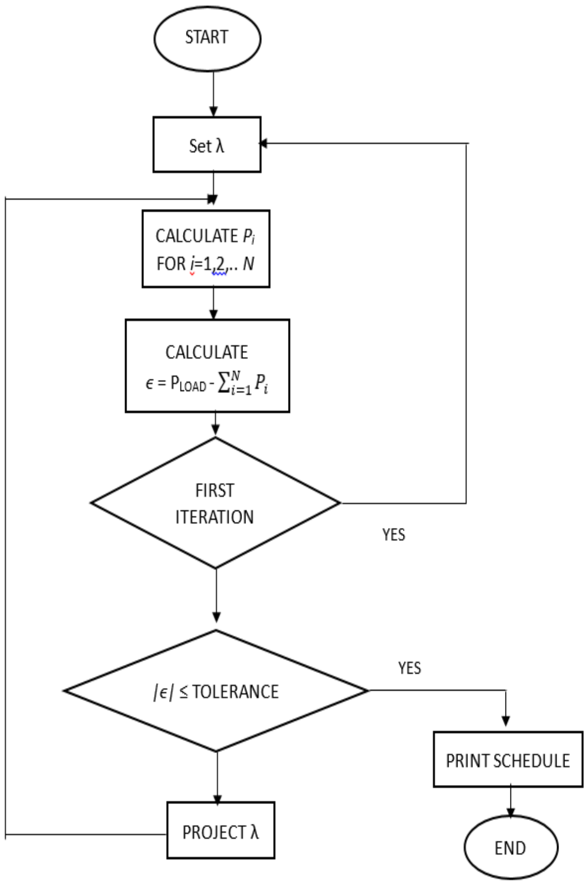

Fig. 1 Flow Chart of Lambda Iteration Method

PSO is a population based optimization techniques based on intelligence scheme developed by Kennedy and Eberhart in 1995. PSO has emerged as the most assuring optimizing scheme for effectively dealing near to global optimization tests. The inspiration of the mechanism is established by the social and corporative nature represented by flying birds. The algorithm stimulates a simplified social milieu in capable solutions of a swarm which means that the single particle basis its search on its own experience and information given by its neighbors in the specified region. Particles are flown in the solution region with their randomized assigned velocities. Among these particles, each particle keeps track of its coordinates in the solution region which are associated with the best fitness it has achieved so far. This is known as pbest. Another best value that is tracked by the particle is the best value obtained so far by any particle in the group of the particles; this best value is known as global best or gbest [10]. The flow chart of Particle Swarm optimization (PSO) is given in Fig. 2.

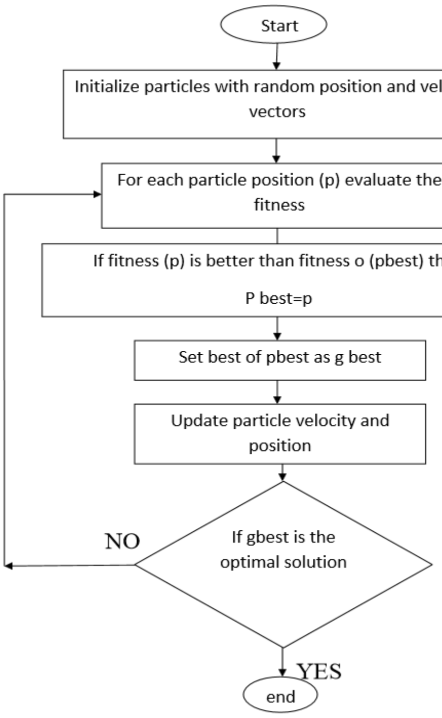

Fig. 2 Flow Chart of PSO

The PSO parameters considered in this work are:

- Population size = 100
- Inertia weight factor, w = 0.7
- No. of Iterations = 80
- Constriction factors, c_1= -0.2, c_2=-0.2

III. SIMULATION AND RESULTS

Lambda iteration method and PSO has been used on a 3 generator set to calculate the fuel cost. The system has been tested for a demand of 200MW. Table-1 shows the minimum and maximum power generation limits (MW), cost coefficients and emission coefficients of a 3 generator set [4].

Various combination of weighting factors were tried to find the power output as shown in Table 2. Table 3 calculates the fuel cost (Rs/hr) of 3 generator set using Lambda iteration method. Table 4 shows the fuel cost (Rs/hr) of 3 generator set calculated using PSO. Table 5 compares the fuel cost (Rs/hr) calculated by using Lambda iteration and PSO.

Table-1: Cost coefficients, Emission coefficients, Power limits of 3 generator set

G	a_i	b_i	c_i	α_i	β_i	γ_i	P_{imin}	P_{imax}
1	0.005	2.45	105	0.0126	-1.355	22.983	20	200
2	0.005	3.51	44.1	0.01375	-1.249	137.370	15	150
3	0.005	3.89	40.6	0.00765	-0.805	363.704	18	180

Table-2: Weighting factors and Power Output For 3 generator sets

W.F.		Lambda iteration			PSO		
w_1	w_2	P_1	P_2	P_3	P_1	P_2	P_3
0	1	67	57.7	74.8	22.933	43.965	132.121
0.1	0.9	71.255	57.724	71.011	48.041	127.119	24.838
0.2	0.8	50.247	71.70	77.94	43.043	20.966	135.99
0.3	0.7	80.59	57.13	61	95.649	21.153	83.197
0.5	0.5	62.75	55.966	50.45	22.515	79.295	98.189
0.7	0.3	109.272	53.61	37.108	22.99	94.09	82.906
0.8	0.2	120.479	51.03	27.94	52.029	119.536	23.433
0.9	0.1	134.98	47.31	16.09	24.886	31.275	143.43
1	0	150	44	6	26.603	20.784	152.61

Table-3: Fuel cost calculated through lambda iteration for different values of weighting factor For 3 generator sets

w_1	w_2	F_1	F_2	F_3	F_T
0	1	291	263.2	359.59	913.79
0.1	0.9	304.96	263.371	342.042	910.373
0.2	0.8	240.729	321.46	374.15	936.339
0.3	0.7	334.5	260.9	296.49	891.89
0.5	0.5	375.2	256.2	249.52	880.92
0.7	0.3	352.1	264.6	187.77	804.47
0.8	0.2	472.75	236.235	153.183	862.168
0.9	0.1	526.79	221.34	104.48	852.61
1	0	585	208	64.12	857.12

Table-4: fuel cost calculated through PSO for different values of weighting factor For 3 generator sets

w_1	w_2	F_1	F_2	F_3	F_T
0	1	166.499	208.083	641.315	1015.897
0.1	0.9	234.216	571.882	140.306	946.404
0.2	0.8	219.716	119.889	662.075	1001.68
0.3	0.7	385.084	120.585	398.84	904.509
0.5	0.5	162.69	120.585	470.76	754.035
0.7	0.3	163.985	418.65	397.472	980.107
0.8	0.2	260.985	535.119	134.502	930.606
0.9	0.1	169.067	158.76	703.566	1031.393
1	0	173.716	119.214	750.713	1043.643

Table-5: Comparison of Fuel cost calculated through Lambda Iteration and PSO for different values of weighting factor For 3 generator set

W.F.		Total Fuel Cost F_T	
w_1	w_2	λ	PSO
0	1	913.79	1015.897
0.1	0.9	910.373	946.404
0.2	0.8	936.339	1001.68
0.3	0.7	891.89	904.509
0.5	0.5	880.92	754.035
0.7	0.3	804.47	980.107
0.8	0.2	862.168	930.606
0.9	0.1	852.61	1031.393
1	0	857.12	1043.643

IV. CONCLUSION AND DISCUSSIONS

As observed from table 5, total cost at w_1=0.5 and w_2= 0.5, is 754.035 Rs/hr. It is concluded that the PSO technique gives the best weighting pattern combination (w_1=0.5, w2=0.5) at which the total cost of 3 generator power system is minimum among all the values of cost calculated with eleven different combinations of weighting Factors. Hence, PSO, being a population based heuristic search approach, which leads to high probable solution with fast convergence characteristics and reduced computational error is a better optimization technique.

REFERENCES

[1] L. Singh and J.S.Dhillon, "Secure multiobjective real and reactive power allocation of thermal power units", International Journal of Electrical Power and Energy Systems, Vol. 30, No. 10, pp. 594-602, 2008.
[2] J. S. Dhillon, S. C. Parti, and D. P. Kothari, "Stochastic economic emission load dispatch," Electric Power Syst. Res., vol. 26, pp. 186–197, 1993.
[3] L.Singh, and J.S. Dhillon, 2009. "Cardinal priority ranking based decision making for economic emission dispatch problem,"International Journal of Engineering, Science and Technology Vol. 1, No. 1, pp. 272-282.
[4] K. Senthil and K. Manikandan. "Economic Thermal Power Dispatch with Emission Constraint and Valve Point Effect loading using Improved Tabu Search Algorithm", International Journal of Computer Applications, Vol. 3, No.9, July 2010.
[5] M. A. Abido, "Environmental/Economic Power Dispatch using Multiobjective Evolutionary Algorithms," IEEE transactions on Power Systems, Vol. 18, No. 4, pp. 1529, November 2003.
[6] M. A. Abido "Multiobjective particle swarm optimization for environmental/economic disparch problem," Elsevier, pp. 1105-1113, 2009.
[7] T. Thakur, K. Sem, S. Saini, S. and S. Sharma, 2006. "A particle Swarm Optmization solution to NO_2 and SO_2 Emissions for Environmentally Constrained Economic Dispatch Problem," IEEE, 2006
[8] Yamille del Valle,G. Venayagamoorthy, Mohagheghi, S., Hernandez, J. C. and R.G Harley, 2008. "Particle Swarm Optimization: Basic Concepts, Variants and Applications in Power Systems", IEEE Transactions on Evolutionary Computation, Vol. 12, No. 2, April, 2008.
[9] J. S. Dhillon and D. P. Kothari. "Power system optimization", Prentice-Hall of India Publication, 2007.
[10] A.J. Wood and B.F. Wollenberg. "Power generation operation and control", Second Edition John Wiley & Sons.
[11] K. Y. Lee and J. Park, "Application of particle swarm optimization to economic dispatch problem: Advantages and disadvantage", Proc.of IEEE PES Power Syst. Conf. Expo, Oct. 2006, pp. 188–192.