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# A STUDY ON : Optimisation of Economic Load Dispatch Problem by PSO

KEYWORDS: particle swarm optimization, Economic dispatch, Piece wise quadratic cost function

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**ABSTRACT** *This paper describes a successful adaptation of the particle swarm optimisation (PSO) algorithm to solve types of economic dispatch (ED) problems in power systems. Economic load dispatch is a non linear optimization problem which is of great importance in power systems[1]. Economic load dispatch (ELD) is the scheduling of generators to minimize the total operating cost depending on equality and inequality constraints. The transmission line loss has been kept as minimum as possible. The study is carried out for three unit test system for without loss and with loss cases.*

**INTRODUCTION**

The primary objective of the economic load dispatch is to allocate the generating units so that the system load may be supplied entirely and most economically satisfying the constraints. The economic dispatch (ED) is a constrained optimization problem and the nature of the problem is to find the most economical schedule of the generating units while satisfying load demand and operational constraints. The problem has been tackled by many researchers in the past.[2]

Classical optimization methods are highly sensitive to starting points and frequently converge to local optimum solution or diverge together. Linear programming methods are fast and reliable, but main weakness is associated with the piece wise linear cost approximation. Non-linear programming methods have a problem of convergence and algorithm complexity. The premature and slow convergence of GA degrades its performance and reduces its search capability. The simulated annealing method is a powerful optimization technique and it has the ability to find near global optimum solutions for the optimization problem. In consequence, conventional techniques become very complicated when dealing with such increasingly complex dynamic system to solve economic dispatch problems, and are further inadequate by their lack of robustness and efficiency in a number of practical applications. In this paper, a brief survey covering recent implementation of soft computing techniques in ED problem is presented[3].

**PROBLEM FORMULATION**

**2.1 Economic Dispatch[4]**

The complicatedness of ELD may be expressed by minimizing the fuel cost of generating units under some constraints. The fuel cost curve is understood as a quadratic function of the active power output from the generating units. The Fuel Cost (FC) function of generating unit is usually described by a quadratic function of power output Pi as:

$$\text{FC}=\sum_{i=1}^{n} a_i P_i^2 + b_i P_i + c_i \ \text{\$/hr.} \qquad \textbf{(2.1)}$$

Where; $a_i$, $b_i$, $c_i$ = cost coefficients of unit i.

$a_i, b_i, c_i$ $a_i$, bi, $c_i$ : fuel cost coefficients of the ith generating unit

N : number of thermal units Subjected to

**1. Power balance constraint**

**PD+PL=ΣPi** **(2.2)**

**2. Generating capacity limits**

**Pimin ≤ Pi ≤ Pimax** **(2.3)**

**Where**

PD = total system demand (MW)

PL = total transmission network loss (MW)

Pi min = minimum power output limit of ith generator (MW)

Pi max = maximum power output limit of ith generator (MW)

PL can be calculated by

$$\text{PL}=\sum_{j=1}^{n} \sum_{i=1}^{n} P_i \ B_{ij} \ P_j \qquad \textbf{(2.4)}$$

Where Bij's = elements of loss coefficient matrix-B.

**Particle Swarm Optimization Concept**

Particle swarm optimization (PSO) is a method for performing numerical optimization without clear knowledge of the gradient of the problem to be optimized. PSO is originally endorsed to Kennedy, Eberhart and Shi and was first planned for simulating social behaviour. The algorithm was basic and it was experiential to be performing optimization. The intelligence EPSO optimizes a problem by maintaining a population of candidate solutions called particles and stirring these particles around in the search-space according to simple formulae. The travels of the particles are guided by the best found positions in the search-space, which are repeatedly updated as better positions are found by the particles.

**PSO parameter**

**(i) Number of Particles**

The typical range of the number of particles is 20-40. Actually for most of the problems 10 particles is large enough to get fine results. For some difficult or extraordinary problems, we should try 100 or 200 particles as well.

**(ii) Dimension of Particles**

Dimension of particles specified by the problem to be optimized.

**(iii) Maximum Velocity**

Vmax defines the maximum change that one particle can take during each iteration.

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**(iv) Acceleration Constants**

The learning factors c1 and c2 determine the impact of the personal best Pbest and the global best Gbest, respectively. If c1 > c2, the particle has the tendency to converge to the best position found by itself Pbesti rather than best position detected by the population Gbest, and vice versa. Most implementations use a setting with c1 = c2 = 2 [27–31]. [5]

**(v) Stopping Condition**

The maximum numbers of iterations that PSO accomplishes or the minimum error requirement are the stopping conditions.

**(vi) Inertia Weight**

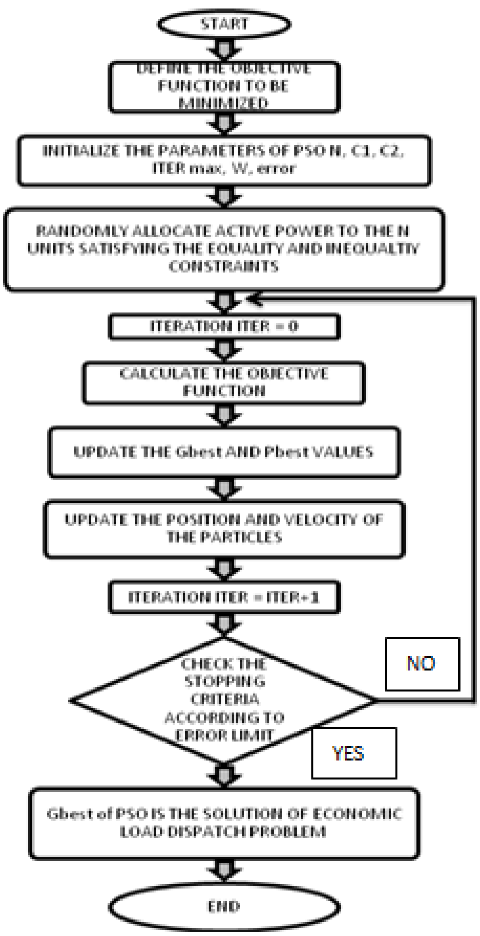
A large value of inertia weight encourages global search while a small value facilitates local exploitation. Therefore, the inertia weight is crucial for the search behaviour of the PSO, and a good balance between exploration and exploitation can be obtained using a dynamical inertia weight. Experimental results show that it is favourable to start with a large inertia weight in the early search stage in order to improve exploration of the search space, and gradually reduce the inertia to achieve more refined solutions in the final search stage to significantly improve its performance.[6]

$$W = W_{max} - \left[\frac{W_{max} - W_{min}}{ITER_{max}}\right] * ITER$$

where $W_{max}$ and $W_{min}$ are the initial and final values of the inertia weight respectively, and $ITER_{max}$ indicates the maximum iteration number. Typically, parameters $W_{max}$ and $W_{min}$ set to 0.9 & 0.4, respectively.

**Basic PSO algorithm[7]**

**`Fig.1 flow chart of PSO**




**Implementation of PSO algorithm to ELD problem**

**Step 1 :**

· The power of a particle of each unit and its velocity are randomly generated for the number of particles set and are checked whether they are within the specified limits.

$P_{gimin} \leq P_{gi} \leq P_{gimax}$

$V_{imin} \leq V_i \leq V_{imax}$

**Step 2 :**

· Each set of solution in the search space should satisfy the following equation.

$$\sum_{i=1}^{N} P_i = P_D + P_L$$

**Step 3 :**

The pbest values of particles which satisfy the equality constraint are utilized in cost evaluation function F.

$$F_t = \sum_{i=1}^{n} a_i P_i^2 + b_i P_i + c_i$$

To calculate total power generation cost, where ai, bi, ci are constants for ith generator. Identify the set of pbest values of particles which provide minimum cost. This set of pbest values (best evalued among pbest) are known as gbest values of generation.

**Step 4 :**

The member velocity v of every individual Pg is updated according to the velocity update equation with respect to pbest and gbest value determined on random basis.

$$P_i^{(u+1)} = P_i^u + V_i^{(u+1)}$$

**C1 and C2 : acceleration constants.**

**w: inertia weight factor**

**Step 5 :**

The velocity components constraint according in the limits from the following condition are checked.

$V_{min} = -0.5 * P_{gimin}$

$V_{max} = -0.5 * P_{gimax}$

**Step 6 :**

The new position of each particle is modified as

$$P_i^{(u+1)} = P_i^u + V_i^{(u+1)}$$

**Step 7 :**

When number of iterations reach maximum, identify the iteration which provides minimum power generation cost and determine to corresponding contribution of power generation by all units.

**EXAMPLE AND RESULT**

Viability of the proposed classical PSO method can be verified by three unit test system is taken for without transmission loss and with transmission loss cases.

**A. Case-1 3-unit system**

The system contains 3 thermal units[1]. Data as follows

F1 = 0.00524P12 + 8.66 P1 + 328.12 Rs/Hr

F2 = 0.00608P22 + 10.05 P2 + 136.92 Rs/Hr

F3 = 0.00592P32 + 9.75 P3 + 59.15 Rs/Hr

$$V_i^{(u+1)} = wV_i^u + C_1 * rand(r_1) * (Pbest - P_{gi}^u) + C_2 * rand(r_2) * (gbest - P_i^u)$$

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240 MW ≤ P1 ≤ 90 MW

238 MW ≤ P2 ≤ 85 MW

100 MW ≤ P3 ≤ 20 MW

**B-Coefficient Matrix:**

B = [0.000134 0.0000176 0.000183

0.0000176 0.000153 0.000282

0.000183 0.000282 0.00162 ]

the corresponding loads is given as 300MW and 450 MW respectively [25]

**Table-1 Three Generator system with optimal scheduling without losses by PSO**

| Load Demand (MW) | Pg1 (MW) | Pg2 (MW) | Pg3 (MW) | Fuel cost (Rs/hr) |
|---|---|---|---|---|
| 300 | 161.076541 | 317.49659 | 155.573291 | 2768.637755 |
| 450 | 152.768436 | 182.873239 | 39.238932 | 4402.969639 |

**(i). Simulation Results of 3 Unit without Loss with 450 MW load**

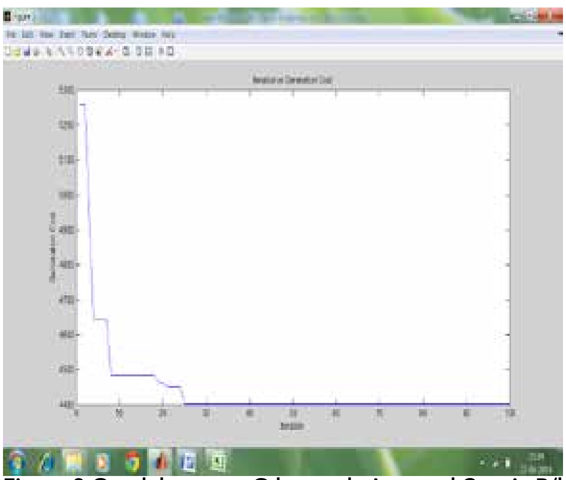

**Figure 2-Graph between G-best solutions and Cost in R/hr for a load of 450 mw**

We can evaluate these results obtained from PSO method with conventional method. This comparison is shown in the below Table.

**Table 2 - Comparison of 3 Generator system without loss with two different methods**

| Power demand (MW) | Fuel Cost (Rs/hr) | |
|---|---|---|
| | Conventional Method | PSO Method |
| 300 | 2768.657850 | 2768.637755 |
| 450 | 4402.989732 | 4402.969639 |

Above table shows that PSO method provides better results.

**(ii) 3-Unit Thermal System with Transmission Losses**

Above system is tested for a load demand of 300 MW and 450 MW [25] using the proposed PSO method including transmission losses which can be calculated with the help of loss matrix Bmn provided in section then the results.

**Table-3 Three Generator system with optimal scheduling with losses by PSO**

| Load Demand MW | Pg1 MW | Pg2 MW | Pg3 MW | Fuel cost Rs/hr |
|---|---|---|---|---|
| 300 | 120.458556 | 87.893538 | 23.134332 | 2814.102989 |
| 450 | 161.957099 | 175.374458 | 66.783262 | 4248.895225 |

**(ii). Simulation Results of 3 Unit with Loss with 450 MW**

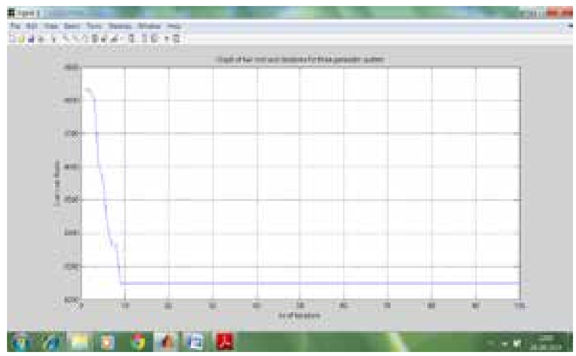

**Figure3-Graph between G-best solutions and Cost in R/hr for a load of 450 mw**

On comparison of above simulation results with Conventional Method; result are as follows into Table-4.

**Table 4 - Comparison of different methods including losses of 3-unit system**

| Power demand (MW) | Fuel Cost (Rs/hr) | |
|---|---|---|
| | Conventional method | PSO Method |
| 300 | 2815.023402 | 2814.102989 |
| 450 | 4249.784023 | 4248.895225 |

**CONCLUSIONS**

We can illustrate important conclusions on the basis of the work done. Some important conclusions are as follows.

The selection of parameters c1, c2 and W is very much important in PSO method. It is assured in various research papers that the good results are obtained when c1 = 2.0 and c2= 2.0 and W value is varied from 0.9 to 0.4 for both cases loss neglected and loss included.

We can see from Table 2 and Table 4 that Classical PSO gives better result than Conventional Method.

**REFERENCE** [1] Shubham Tiwari1, Ankit Kumar2, G.S Chaurasia3, G.S Sirohi4, ECONOMIC LOAD DISPATCH USING PARTICLE SWARM OPTIMIZATION," IJAIEM Volume 2, Issue 4, April 2013. | [2] Zhang Zhisheng,"Quantum-behaved particle swarm optimization algorithm for economic load dispatch of power system,"Qingdao University, School of Automation Engineering, Qingdao 266071, China. ELSEVIER Volume 37, Issue 2, March 2010, Pages 1800–1803 | [3] Ranjit Roy a,*, S.P. Ghoshal b," A novel crazy swarm optimized economic load dispatch for various types of cost functions," S.P. International Journal of Electrical Power and Energy Systems vol. 30 issue 4 May, 2008. p. 242-253 | [4] Wood A. J. and Wollenberg B. F, "Power generation, operation and control", John Wiley & Sons, New York, IIIrd Edition. | [5] Lingfeng Wang_, Chanan Singh, " Reserve-constrained multi area environmental / economic dispatch based on particle swarm optimization with local search." ELSEVIER Volume 22, Issue 2, March 2009, Pages 298–307 | [6] Dun-wei Gong, Yong Zhang *, Cheng-liang Qi, "Environmental/economic power dispatch using a hybrid multi-objective optimization algorithm," ELSEVIER Volume 32, Issue 6, July 2010, Pages 607–614 | [7] M.A. Abido, "Multiobjective particle swarm optimization for environmental / economic dispatch problem," ELSEVIER Volume 79, Issue 7, July 2009, Pages 1105–1113. |