ECONOMIC LOAD DISPATCH SOLUTIONBY USING ADVANCED PSO

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Abstract: Economic load dispatch is a vital optimisation task in facility operation for allocating generation among the committed units specified the constraints obligatory square measure glad and also the energy necessities in terms of British thermal units per hour (Btu/h) or dollar per hour ($/h) square measure decreased . This paper used particle swarm optimisation techniques for answer of economic load dispatch drawback with ramp rate constraints. And later it's compared with CPSO. For the testing of the planned PSO information of half-dozen generating unit system is taken into account. during this paper the ability and utility of the PSO and CPSO formula is incontestable through its application for 6 generator systems with constraints.
Keywords: Economic Load Dispatch (ELD),Particle swarm optimization (PSO), (CPSO)PSO with constriction factor, Ramp rate limits.

I. INTRODUCTION

The monetary planning is the on-line financial burden dispatch, wherein it is required to disperse the heap among the producing units which are really paralleled with the framework, so as to limit the absolute working expense of creating units while fulfilling framework correspondence and imbalance limitations. For any predefined burden condition, ELD decides the power yield of each plant (and each creating unit inside the plant) which will limit the general expense of fuel expected to serve the framework load [1]. ELD is utilized continuously vitality the board control framework control by most projects to designate the all out age among the accessible units. ELD centers after organizing the generation cost at all power plants working on the framework.

Numerous old style methodologies were utilized for taking care of financial burden dispatch issue utilizing diverse target capacities. Different customary strategies like lambda cycle strategy, slope based strategy, Bundle technique [2], nonlinear programming [3], blended whole number straight programming [4], [5], dynamic programming [8], straight programming [7], quadratic programming[9], Lagrange unwinding technique [10], direct search technique [12], Newton-based techniques[11], [12] and inside point strategies [6],[13] detailed in the writing are utilized to take care of such issues.

Traditional strategies have many downside, for example, nonlinear programming has algorithmic unpredictability. Direct programming strategies are quick and solid however require linearization of target work just as imperatives with non-negative factors. Quadratic writing computer programs is an extraordinary type of nonlinear programming which has a few detriments related with piecewise quadratic cost estimation. Newton-based technique has a downside of the intermingling attributes that are touchy to starting conditions. The inside point strategy is computationally proficient yet experiences terrible introductory end and optimality criteria.

As of late, unique heuristic methodologies have been demonstrated to be viable with promising execution, for example, transformative programming (EP) [16], [17], reenacted toughening (SA) [18], Tabu inquiry (TS) [19], design search (PS) [20], Genetic calculation (GA) [21], [22], Differential advancement (DE) [23], Ant state optimization[24], Neural system [25]and molecule swarm improvement (PSO) [26], [29], [30], [32]. Despite the fact that the heuristic techniques don't generally ensure finding all inclusive ideal arrangements in limited time, they frequently give a quick and sensible arrangement. EP is fairly moderate meeting to a close ideal for certain issues. SA is very tedious, and can't be used effectively to tune the control parameters of the strengthening plan. TS is troublesome in characterizing successful memory structures and systems which are issue subordinate. GA here and there comes up short on a solid limit of creating better posterity and causes moderate union close worldwide ideal, some of the time might be caught into nearby ideal. DE eager refreshing standard and characteristic differential property more often than not lead the registering procedure to be caught at nearby optima.

Particle-swarm-optimization is a population-based evolutionary technique first introduced by [26], 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. Now, the PSO has been extended to power systems, artificial neural network training, fuzzy system control, image processing and so on.

The main objective of this study is to use of PSO and CPSO for the obtaining optimum solution of then economic load dispatch problem. The CPSO has the ability to explore the solution space than in a standard PSO.The proposed method focuses on solving the economic load dispatch with ramp rate constraint. The feasibility of the proposed method was demonstrated forthree and six generating unit system.

II. PROBLEM FORMULATION

Economic load dispatch is important problems to be solved in the operation and planning of a power system the primary

concern of an ELD problem is the minimization of the total generation fuel cost. The total cost generated that meets the demand and satisfies all other constraints associated is selected as the objective function.
The ED problem objective function is formulated mathematically in (1) and (2),
$F_T = \text{Minf}(FC)$(1)

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

Where,F_T is the Fuel cost function,and a_i, b_i and c_i are the cost coefficients.

1.1 CONSTRAINTS
This ELD problem considered the following constraints,

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,

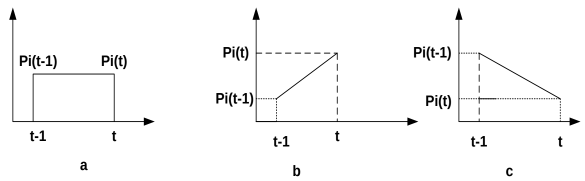
$\sum_{i=1}^{n} P_i = P_D + P_L$(3)

Where, $P_D$is the total system demand and P_L is the total line loss.
power generation 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.

$P_i^{min} \le P_i \le P_i^{max}$ (4)

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.

Ramp rate limit
The actual operating ranges of all on-line units are restricted by their corresponding ramp-rate limits. Fig.1 shows three possible situations in which a unit is on-line from time interval (t-1) to t. Fig.1 a shows the unit operating in steady-state conditions, fig.1 b, shows the unit increasing its power generation whereas Fig.1 c shows the unit decreasing the power generation output.



Shows steady state operation,
Shows increasing the level of the power generation and
Shows decreasing the power output
Fig. 1. Three possible situations of on-line generation limit

As generation increases
$P_i(t) + P_i(t-1) \le UR_i$ (5)

2) As generation decreases

$P_i(t-1) - P_i(t) \ge DR_i$ (6)

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 (7)

$P_i^{max}(t)$= min $(P_i^{max}, P_i(t-1) - UR_i)$ (8)

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

III. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization was first introduced by Kennedy and Eberhart in the year 1995 [26]. 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 swarmscollect information from eacharray constructed by their respective positions. The particles update their positionsusing the velocityof 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)

$V_i^{(K+1)} = WV_i^K + c_1 rand_1 \times (Pbest_i - S_i^K) + c_2 rand_2 \times (gbest - S_i^K)$ (10)

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

Where, V_i^k is velocity of individual i at iteration k, 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,
Pbest is the best position of individual i and
gbest 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_l and c_2 are often set to be 2 according to past experiences. The term $c_{1*}rand_1x(pbest, -S^k_1)$ is called particle memory influence or cognition part which represents the private thinking of the itself and the term $c_{2*r}and_2)\times(gbest - S^k_1)$ 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 0.9to 0.4 quite often during a run, the following weighing function is used in (10)

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

Where, W_{max} is the initial weight,W_{min} is the final weight, $Iter_{max}$is the maximum iteration number and iteris the current iteration position.

3.1 PSO with constriction factor (CPSO)
For getting better solution the standard PSO algorithm, used classical PSO , the constriction factor is used in this algorithm. Updating of velocity used in basic PSO given in (10) can be changed in CPSO as follows,

$$V_i^{(K+1)} = C * [V_i^K + c_1 Rand_1 \times (Pbest_i - S_i^K) + c_2 Rand_2 \times (gbest - S_i^K)] \quad (13)$$

$$C = \frac{2}{\left|2-\emptyset-\sqrt{\emptyset^2-4\emptyset}\right|} \qquad (14)$$

Where, C is the constriction factor, $\emptyset = c_1+c_2$

3.2 ALGORITHM FOR ED PROBLEM USING CPSO
The algorithm for ELD problem with ramp rate generation limits employing PSO for practical power system operationis 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 velocity by using (13)
Step7:-Update position by using (11)
Step8:-Apply stopping criteria.

Test Data and Results
TEST CASE 1
The test results are obtained for three-generating unit system in which all units with their fuel cost coefficients. This system supplies a load demand of 150MW. The data for the individual units are given in Table 1. The best result obtained by PSO and CPSO for different population size is shown in Table 1 and table 2.

Table 1
Capacity, cost coefficients and ramp- rate limits of 3 generating unit, Load 850MW.

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

B_{ij}	0.0006760	0.0000953	-0.0000507
	0.0000953	0.0005210	0.0000901
	-0.0000507	0.0000901	0.0002940
B_{i0}	-0.007660	-0.00342	0.01890
B_{00}	0.40357		

Table 3
Results of three generating unit system for the demand of 850MW

Unit Power Output	PSO	CPSO
P1(MW)	146.03	145.8978
P2(MW)	337.93	339.9597
P3(MW)	550.17	548.971
Power loss(MW)	183.043	182.7293
Total Power Output	1033.958	1033.7
Total Cost($/h)	9843.228	9841.228
Computation time (Sec)	0.783	0.7501

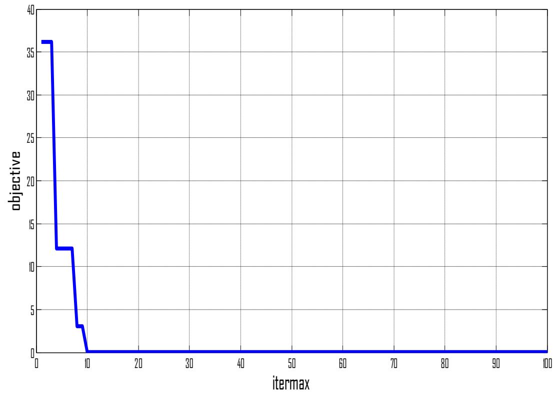


Fig.2. Convergence characteristic of CPSO for 3 generating units.

TEST CASE II
The test results are obtained for six-generating unit system in which all units with their fuel cost coefficients. This system supplies a load demand of 1263MW. The data for the individual units are given in Table 4 the best result obtained by PSO and CPSO for different population size is shown in table 5.

Table 4: Capacity, cost coefficients and ramp- rate limits of 6 generating units, load 1263MW

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

Table 5: Results of six generating system for the demand of 1263 MW

Unit Power Output	PSO	CPSO
P1(MW)	423.84	471.66
P2(MW)	115.03	140.03
P3(MW)	265.21	240.06
P4(MW)	136.73	149.97
P5(MW)	180.65	173.78
P6(MW)	85.83	99.97
Loss	11.22	12.38
Total Power Output	1275.46	1275.31
Total Cost($/h)	15489	15454.87
Computation time	0.7621	0.7201

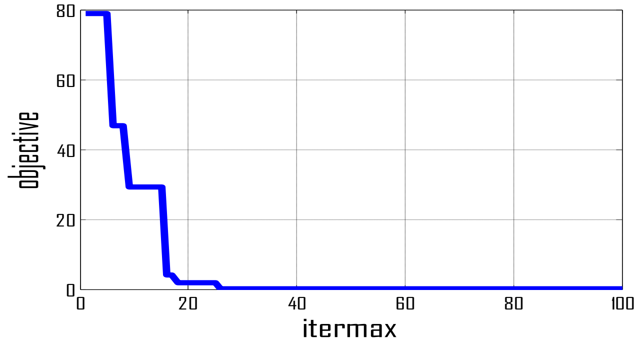


Fig.2. Convergence characteristic of CPSO for 6 generating units.

Result Analysis
To assess the efficiency of the proposed CPSO approaches in this papertested for a case study of3 thermal generating units with ramp rate limits data given in table 1 and table 3. The proposed algorithm runs on a 1.4-GHz, dual to core-2 processor with 2GB DDR of RAM.

The ELD data tested for different population size as shown in table 3 of50 iteration used for obtaining results. Constants are taken in this study are acceleration coefficients are c_1=c=2, W_{max}=0.9 and W_{min}=0.4.

The optimum result obtained by proposed approach for 3 thermal generating units is given in table2 and table 3. The minimum averagecost obtained by CPSO is$9841.228/h for the population size of 50. Fig.1 shows the improvement in each iteration for the six generation unit system respectively.

Similarly result obtained by CPSO for 6 thermal generating units shown in table 5 shows that minimum average cost is $15454.87/h for the population size of 20. Convergence characteristic of CPSO for 6 thermal generating units is shown in figure 2.

IV. CONCLUSIONS

This work utilized another PSO enhancement procedure for the arrangement of financial burden dispatch with incline rate requirements. The proposed strategy has been connected to two diverse experiments and got the ideal arrangement of the issue. The examination of results has exhibited that CPSO outflanks different strategies as far as a superior ideal solution.However, the significantly better speed of calculation takes into account extra searches to be made to build the trust in the arrangement. By and large, the CPSO calculations have been demonstrated to be exceptionally useful in considering improvement issues in power frameworks.

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