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Optimization of Capacity Limits and Fuel Cost Coefficients for 15 Generating Units for the Demand Load of 2630mw Using PSO With Time Varying Acceleration Coefficients

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Abstract--*Economic load dispatch is the approach of allocating current producing devices in this kind of manner to contented the load demand and satisfy the constraints so that the full generation price at thermal energy plant is minimized. Particle swarm optimization is an optimization approach based on populace of social behavior is implemented on various nonlinear optimization problem. This article used PSO and a brand new PSO based totally on time varying of acceleration coefficients. This new PSO has the capacity to discover the debris by various the acceleration coefficient within the search spaces more correctly and will increase their convergence prices. This work used both of PSO strategies to achieve the most fulfilling results of ELD hassle. Usefulness of the PSO and TVACPSO algorithm is verified for test data of IEEE bus system of 6 and 15 generating units. Results acquired through PSO and TVAC PSO additionally in comparison with the effects of the literature.*

Keywords:-- Particle swarm optimization (PSO), Economic Load Dispatch (ELD), Time varying acceleration particle swarm optimization (TVAC PSO)

INTRODUCTION

Electric application gadget is interconnected to reap the advantages of minimum production cost, maximum reliability and better working conditions. The financial scheduling is the on-line economic load dispatch, in which it's miles required to distribute the weight a number of the producing gadgets which are really paralleled with the device, in such a way as to reduce the total operating price of generating units at the same time as pleasing system equality and inequality constraints. For any exact load circumstance, ELD determines the electricity output of every plant (and each generating unit within the plant) as a way to reduce the overall value of gasoline had to serve the gadget load [1]. ELD is used in actual-time strength management electricity machine control by means of maximum programs to allocate the total generation many of the available units. ELD focuses upon coordinating the manufacturing price in any respect strength vegetation operating on the device. Conventional in addition to modern-day methods have been used for fixing financial load dispatch trouble using exclusive goal functions. Various traditional strategies like lambda new release technique, gradient-primarily based technique, Bundle method [2], nonlinear programming [3], combined integer linear programming [4], dynamic programming [8], linear programming [7], quadratic programming [9], Lagrange rest approach [10], direct seek method [12], Newton-based strategies [11] and indoors factor techniques [6] said within the literature are used to clear up such problems. Conventional techniques have many draw back inclusive of nonlinear programming has algorithmic complexity. Linear programming strategies are rapid and dependable but require linearization of objective characteristic as well as constraints with non-negative variables. Quadratic programming is a special form of nonlinear programming which has a few hazards related to piecewise quadratic fee approximation. Newton-primarily based approach has a downside of the convergence characteristics which are touchy to preliminary conditions. The interior factor technique is computationally efficient but suffers from terrible preliminary termination and optimality criteria. Recently, distinctive heuristic processes were proved to be powerful with promising performance, which include evolutionary programming (EP) [16], [17], simulated annealing (SA) [18], Tabu seek (TS) [19], sample search (PS) [20], Genetic algorithm (GA) [21], [22], Differential evolution (DE) [23], Ant colony optimization [24], Neural network [25] and particle swarm optimization (PSO) [26].Although the heuristic methods do not continually assure discovering globally most fulfilling answers in finite time, they frequently offer a quick and reasonable solution. EP is as a substitute sluggish converging to a near foremost for some problems. SA could be very time ingesting, and can't be applied without difficulty to music the manage parameters of the annealing time table. TS is hard in defining powerful reminiscence structures and techniques which might be problem established. GA on occasion lacks a robust ability of manufacturing better offspring and causes slow convergence near global top-quality, sometimes can be trapped into nearby foremost. DE greedy updating precept and intrinsic differential assets normally lead the computing method to be trapped at local optima.

Particle-swarm-optimization (PSO) technique is a populace-based Evolutionary technique first brought in [26], and it is inspired with the aid of the emergent movement of a flock of birds attempting to find food. In comparison with different EAs inclusive of GAs and evolutionary programming, the PSO has similar or maybe superior seek overall performance with faster and extra strong convergence costs. Now, the PSO has been prolonged to electricity structures, artificial neural network schooling, fuzzy machine control, picture processing and so on. The most important intention of this work is to apply of PSO with time varying acceleration coefficient to clear up the energy machine economic load dispatch to enhance its worldwide search capability. This new improvement gives debris extra opportunity to discover the answer space than in a trendy PSO. The proposed method specializes in fixing the monetary load dispatch with constraint. The feasibility of the proposed method becomes demonstrated for 3 and six generating unit device.

PROBLEM FORMULATION

ELD is one of the most important problems to be solved in the operation and planning of a power system the primary concern of an ED problem is the minimization of its objective function. 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),

FT=Min f(FC) …………………(1)

FC=i=1nai×Pi2+bi×Pi+ci …………(2)

Where, FT is the main objective function, a_i, b_i and c_i are the cost coefficients.

2.1 CONSTRAINTS

This model is subjected to the following constraints.

1) 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,

i=1nPi=PD+PL …………………………..(3)

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

2) Limits of Power Generation

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.

$Pi_{min} \leq Pi \leq Pi_{max}$ …………….(4)

Where, Pi is the output power of i_{th} generator, Pi,min and Pi,max is the minimum and maximum power outputs of generator i respectively.

PARTICLE SWARM OPTIMIZATION

Particle swarm optimization become first delivered by using Kennedy and Eberhart within the yr. 1995 [26]. It is an interesting new methodology in evolutionary computation and a population-based optimization device. PSO is motivated from the simulation of the behavior of social systems together with fish training and birds flocking. It is an easy and powerful optimization tool which scatters random particles, i.e., answers into the problem space. These particles, referred to as swarms collect statistics from each array built by their respective positions. The particles update their positions using the rate of articles. Position and velocity are each up to date in a heuristic manner the usage of steering from particles' personal revel in and the experience of its associates. The position and velocity vectors of the ith particle of a d-dimensional search space can be represented as $P_i=(p_{i1},p_{i2}\ldots\ldots p_{id})$ and $V_i=(v_{i1},v_{i2}\ldots\ldots v_{id},)$ respectively. On the basis of the value of the evaluation function, the best previous position of a particle is recorded and represented as $P_{besti}=(p_{i1},p_{i2}\ldots\ldots p_{id})$, If the gth particle is the best among all particles in the group so far, it is represented as $P_{gbest}=g_{best}=(p_{g1},p_{g2}\ldots\ldots p_{gd})$. The particle updates its velocity and position using (5) and (6).

Vi(K+1)=WViK+c1rand1×Pbesti-SiK+c2rand2×gbest-SiK (5) Si(K+1)=SiK+ViK+1 (6)

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-The best position of individual i, and gbest -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. *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 0.9 to 0.4 quite often during a run, the following weighing function is used in (5)

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W=Wmax-Wmax-Wminitermax×iter (7)

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

ALGORITHM FOR ELD PROBLEM USING PSO

The algorithm for ELD problem with ramp rate generation limits employing PSO for practical power system operation is 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 (8)*

Step7:- *Update position by using (6)*

Step8:- *Apply stopping criteria.*

TEST DATA AND RESULTS

TEST CASE 1

In this test case we considered test data of 6 generating units. The test results are obtained for 6 generating unit system in which all units with their fuel cost coefficients. This system supplies a load demand of 1263 MW. The data for the individual units and transmission loss coefficients matrices are given in Table I. The best result obtained by TVACPSO and PSO for six-unit system with loss coefficients and without loss coefficients is shown in Table II.

TEST CASE 2

In second case of study we considered test data of 15 generating units. The test results are obtained for 15 generating unit system in which all units with their fuel cost coefficients. This system supplies a load demand of 2630 MW. The data for the individual units is given in Table III. The best result obtained by PSO for different population size is shown in Table IV.

Table I: Capacity limits and fuel cost coefficients for 6 generating units for the demand load of 1263MW

Units	a_i($)	b_i($/Mw)	c_i($/Mw^2)	P_{min}	P_{max}
1	240	7	0.0070	100	500
2	200	10	0.0095	50	150
3	220	8.5	0.0090	80	300
4	200	11	0.0090	50	150
5	220	10.5	0.0080	50	200
6	190	12	0.0075	50	120

Table II: Results of 6 Generating Units after 50 trials

Generating units	TVAC PSO	
	Without Loss	With Loss
P1(MW)	429.354	461.4751
P2(MW)	133.4669	120.8947
P3(MW)	300	247.2173
P4(MW)	144.8439	150
P5(MW)	162.0876	191.3338
P6(MW)	93.2476	94.8865
Loss		2.807(MW)
TPG***	1263	1265.807
FC($/h)*	15308.17	15350.77
CT (Sec)**	0.89	0.73
** Computational Time, * Fuel Cost, *** Total Power Generation		

Table III: Capacity limits and fuel cost coefficients for 15 generating units for the demand load of 2630MW

Units	a_i($)	b_i($/Mw)	c_i($/Mw^2)	P_{min}	P_{max}
1	671.03	10.07	0.000299	150	455
2	574.54	10.22	0.000183	150	455
3	374.59	8.80	0.001126	20	130
4	374.59	8.80	0.001126	20	130
5	461.37	10.40	0.000205	150	470
6	630.14	10.10	0.000301	135	460
7	548.20	9.87	0.000364	135	465
8	227.09	11.50	0.000338	60	300
9	173.72	11.21	0.000807	25	162
10	175.95	10.72	0.001203	20	160
11	186.86	11.21	0.003586	20	80
12	230.27	9.90	0.005513	20	80
13	225.28	13.12	0.000371	25	85
14	309.03	12.12	0.001929	15	55
15	323.79	12.41	0.004447	15	55

Result Analysis

The ELD data tested for different population size as shown in table II for 6 generating units and in table IV, 15 generating units for 50 iteration used for obtaining results. Constants are taken in this study are acceleration coefficients are c_1=c_2=2, W_{max}=0.9 and W_{min}=0.4. The optimum result obtained by proposed approach for 6 thermal generating units is given in table III and 15 thermal generating units given in table IV. The minimum average cost obtained for 6 generating units obtain by TVACPSO is 15308.17 $/h for the population size of 50.

The minimum average cost obtained for 15 generating units obtain by PSO is 32654.82 $/h for the population size of 50.

Table IV: Results for 15 generating units after 50 trials

Generating Units	PSO	TVAC PSO
P1	351.70	405.345
P2	310.06	415.3405
P3	52.08	102.4841
P4	93.35	127.4206
P5	287.437	354.7904
P6	352.63	460
P7	63.98	376.5076
P8	276.846	64.3009
P9	52.91	25.4005
P10	162.903	136.7247
P11	78.71	40.7512
P12	58.281	36.6468
P13	23.98	31.148
P14	47.62	22.4836
P15	33.42	30.656
TPG*	2630(MW)	2630(MW)
MFC($/hr)*	33162.04	32654.82
CT(sec)*	1.02	1.72

* Total power generation,
**Minimum fuel cost($/hr),
*** Computation Time

CONCLUSION

This paper introduces TVACPSO optimization approach for the solution of power system economic dispatch with constraints. The proposed method has been applied to different test case. The analysis results have demonstrated that PSO outperforms the other methods in terms of a better optimal solution. However, the much-improved speed of computation allows for additional searches to be made to increase the confidence in the solution. Overall, the TVACPSO algorithms have been shown to be very helpful in studying optimization problems in power systems.

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