

A New PSO Techniques for the Optimization of Economic Load Dispatch of Thermal Generated Power

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Abstract

Generation of electrical power at a thermal power plant at low cost is a great challenge. As the cost of fuel, transportation, and maintenance increased, the generation of power cost per unit also increases. Economic load dispatch analysis is one of the ways to use the all available generating units, generate the power in such a way so that demand can be fulfilled. It also helps us to maintain the different constraints. The latest PSO with strong capability of searching global solution proposed in the work. It can handle the economic load dispatch without affecting the constraints limits. The proposed new PSO has the capability to move the particles in the area of examining very fast. And evaluate the solution effectively in very short of the span. Work also extended and solved for ELD problem of the test data of 2, 3 and 6 generating unit systems using PSO, WIPSO, SOH-PSO and new PSO. The result with new PSO shows that the associated algorithm is effective and efficient compared with PSO techniques used in this work.

Keywords: PSO with improved Weight parameter, Economic load dispatch, Particle Swarm Optimization, New Particle Swarm Optimization, CPSO(Particle Swarm Optimization with constriction factor), Constraints.

1. Introduction

Electrical power systems are the very large interconnected arrangement. For the effective, economical and reliable operation of large interconnected power system, it requires a proper analysis and opting the method of operation. Study of economic load dispatch helps us to operate power systems economical and efficient manner, therefore improves the supply of energy without any disturbances. The economic load dispatch is an online process of allocating load demand between the generating units available at that time to minimize the overall power generation cost and assures that it does not violate the constraints.

The characteristic of classical economic load dispatch problem is linear in nature. If include the different types of constraints, then it can be considered as the nonlinear optimization problem. For nonlinear characteristic obtaining it, optimal solution becomes the very difficult task. Many classical and modern optimization techniques used to solve such nonlinear problem. Quadratic programming is a conventional technique [4] used for the solution of economic load dispatch, this work considered network security constraints. This method has the drawback that it is unable to solve such problem with transmission losses. The effectiveness of harmony search method was proposed for the solution of economic load dispatch [5], considered with transmission loss. Authors of [1,9] consider the valve point loading effect and formulate the ELD and it is optimized by PS(pattern search) method. This method is very much particular about the parameter selection and fails when parameters changes. The parametric quadratic programming method was proposed by the authors of [4], for the solution of classical economic load dispatch problem. This meth-

od has the ability to increase the convergence rate, but it takes large memory space.

Classical methods like Lagrangian[10], and Simulation annealing[11], used for the analysis of economic load dispatch. They also include some constraints like valve point loading effects, ramp rate limits etc. Since the classical optimization techniques have many drawbacks and unable to give the global solution of the problem. Many new approaches are presented in literature used for the solution to the economic load dispatch problem.

Artificial Neural Network approach was proposed by [12], for the solution of economic load dispatch, it is tested for the data of IEEE -6 bus system. PSO approach for ELD solution given by [7], including valve point loading effects. The proposed PSO algorithm is tested for the data of thirteen and forty generators system. An ED problem with various constrains like multi- fuel, prohibited operating zone, ramp rate limit and spinning reserved proposed by [2], using GA with the real coded algorithm.

In this work, proposed PSO and the new variant of PSO like C-PSO(Constriction factor-PSO), Improved inertia weight PSO(WIPSO)[14], SOH-PSO [6]and new PSO (MR-PSO) [3], for the solution of ELD problem. The proposed methods are tested for the data of 2, 3 and six generating unit system. The results obtained by MR-PSO compared with the results of other PSO techniques used in this work as well as algorithm shown in literature, shows that it give the better result than other algorithms and PSO variants.

2. ELD Formulation

Economic Generation Cost Function: Characteristic of fuel cost of generating power plant formulated as shown in Eq. (1) and eq. (2).

$$F_T = \text{Min } f(\text{FC}) \quad (1)$$

$$f(\text{FC}) = \sum_{i=1}^N a_i P_i^2 + b_i P_i + c_i \quad (2)$$

Where F_T is the total generation cost, $f(\text{FC})$ is the cost function in terms of power generation, a_i , b_i , & c_i are the cost coefficients, P_i is the power generated by i th generating units, N is the number of generators.

2.1. Constraints

2.1.1. Power balance constraints

The total power generated at thermal power plant should be equal to the sum of overall load require and loss of the line and it is represented as in eq. (3).

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

$$P_L = \sum_{i=1}^n \sum_{j=1}^n P_i B_{ij} P_j \quad (4)$$

Where P_D & P_L is the total system demand & line loss respectively, B_{ij} is the line loss elements.

2.1.2 Generator Limits

Output power generated by each generating unit should recline between the maximum and minimum limits,

$$P_i^{\min} \leq P_i \leq P_i^{\max} \quad (5)$$

Where P_i is the output power of i th generator, P_i^{\min} & P_i^{\max} is the minimum and maximum generated power of i th generator respectively.

3. New Particle Swarm Optimization (Moderate Random PSO)

PSO is a popular optimization tool helps for solving the ELD problem. Classical PSO needs to modify in such a way so that exploration speed of particles improved and gives global solution quickly. HaoGao and Wenbo [15], first introduced the PSO with moderate random search system commonly known as MR-PSO. Moderate random explores strategies to enhance the universal search ability of the particles and convergence rate not slow down. Introduced New PSO resolve the problem of classical PSO, and its performance is better than classical PSO for both linear and non-linear ELD problem.

3.1. Initialization of particles

In new PSO the particles are randomly generated between the maximum and minimum limits of the power generated at thermal plants as given below,

$$P_{\text{Initial}} = P_{\text{imin}} + \text{rand}(P_{\text{imax}} - P_{\text{imin}}) \quad (9)$$

Where P_{Initial} : the position of particles, rand : random value between 0-1, P_{imax} and P_{imin} is the maximum and minimum value of the produced power of generator correspondingly.

3.2. Position of the particles

The position of the particles is updated for the i th particle at the $(K+1)$ th iteration using eq. (10)

$$S_i^{K+1} = P_d + \alpha \lambda (m_{\text{best } i} - S_i^K) \quad (10)$$

Where

$$m_{\text{best } i} = \sum_{i=1}^N \frac{P_{\text{best}}}{N} \quad (11)$$

Where N show the size of the population, α is a constant and its value change from 0.45 to 0.35.

3.3. Attraction Factor

In the new PSO used one of the attractor factors which help the particles to move in the direction of the global solution. Actually, at starting particles are moving randomly, this factor helps such random moving particle to move in right direction, so they can achieve the global solution and not take much time. Attraction factor is given as in eqn.(12)

$$P_d = \text{rand}_0 P_{\text{best}} + (1 - \text{rand}_0) g_{\text{best}} \quad (12)$$

Where rand_0 represent a random value between 0 and 1, P_{best} shows the best value of particle and g_{best} is the global best value of P_{best} values.

$$\lambda = \frac{\text{rand}_1 - \text{rand}_2}{\text{rand}_3} \quad (13)$$

Where rand_1 and rand_2 are considered as random variable between 0 and 1 and rand_3 is a random variable within $[-1, 1]$.

3.4. Objective Function for MR-PSO

Since ELD is the problem of minimization, need to set an objective function for the proposed new PSO. Generally when total power generated by the thermal plant in equal to the load demand called the economic dispatch of power. So here we consider our objective function as the error. When error will be zero, obtained results are the global best values of generated power. That global value use for calculation of total fuel cost of the thermal plant. So objective function used in algorithm is given below,

$$\text{error} = (\text{Load demand} - \text{total generation})^2 / 2 \quad (14)$$

4. Algorithm of MR-PSO For Economic Load Dispatch Problem

For the solution of proposed test case required following algorithm steps

1. Takes the maximum and minimum value of power generated at thermal power plan.
2. Initialize particle randomly.
3. Evaluate the
4. Initial position and velocity of the particle respectively.
5. Set the personal best and global best value zero initially.
6. Select the load demands for the particular case of study.
7. Set the number iterations maximum value.
8. Set the count of iteration= current iteration+1
9. Insert fuel cost formulation with constraints.
10. Insert the algorithm objective function as given in equation (14).
11. Evaluate personal best and global best value and compare it with initial value of personal best and global best respectively.

12. Update the position of the particles as given in eq. (10).
13. Check the limits violation, where they are in the limits of constraints or not.
14. Obtained the global best value and calculate the total generation cost of the plant.
15. Stop the algorithm when complete total number of iterations.

5. Case Study and Results

In this work considered three different cases. First case study takes for 2 generating unit system [13], Second case study considered for 3 generating unit systems [13], and third case study consider for six generating unit system [8].

Table 1: Results of two generating unit system, demand=250MW

Unit Output	Power	Lambda Iteration	PSO	CPSO	WIPSO	MRPSO
P1(MW)	128.510	128.59	127.106	127.57	128.5	
P2(MW)	121.532	121.40	122.89	122.42	121.24	
Total Power Output (MW)	250	250	250	250	250	
Total Fuel Cost(\$/h)	2516.00	2515.05	2515.20	2515.14	2511.13	
Computation time(Sec.)	1.612	0.6467	0.7301	0.6008	0.480	

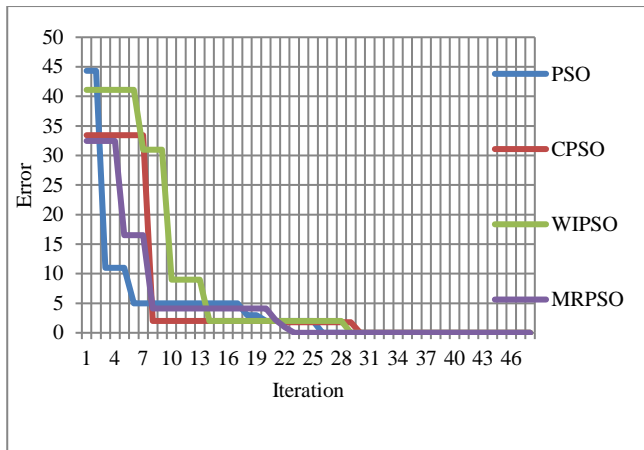


Fig.1: Convergence characteristics of different PSO algorithms for 2 generating unit systems.

Table 2: Results of three generating unit system for the load of 850

Unit output Power	Lambda Iteration	PSO	CPSO	WI-PSO	MR-PSO
P1(MW)	121.034	121.101	127.62	126.52	122.581
P2(MW)	340.032	340.032	354.16	354.71	336.221
P3(MW)	389.023	389.023	368.16	368.763	391.198
Total Power Output (MW)	850	850	850	850	850
Total Generation Cost(\$/h)	8198.92	8196.261	8196.7	8197.16	8194.20
Computation Time(Sec.)	1.299	0.530	0.497	0.428	0.391

Table 3: Results of 6 generating unit system for the load of 700MW

Unit Power Output	GA[12]	PSO	CPSO	WIPSO	MR-PSO
P1(MW)	27.3009	10	20.156	92.3	61.43
P2(MW)	15.6124	72.508	63.740	15.08	36.93
P3(MW)	120.310	35	139.73	52.76	129.11
P4(MW)	116.775	116.20	128.96	76.9	122.39
P5(MW)	226.837	260.17	215.81	262.69	176.04

P6(MW)	212.450	206.12	131.54	200.17	174.03
Total Power Output (MW)	700	700	700	700	700
Total Generation Cost(\$/h)	820.94	819.35	818.61	817.38	810.51
Computation time (sec)	1.812	0.7106	0.672	.904	0.529

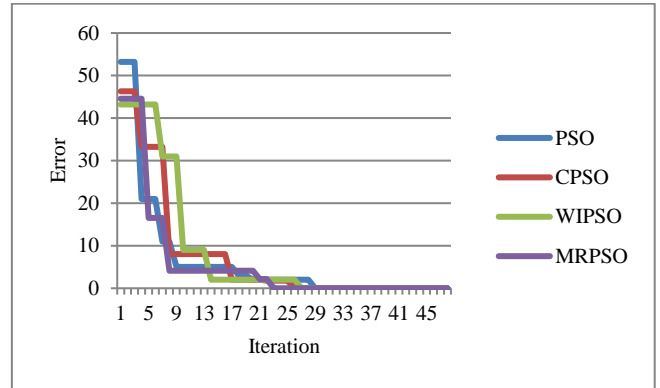


Fig.2: Convergence characteristics of different PSO used for evaluating results of the three generating units for 850 MW load demand.

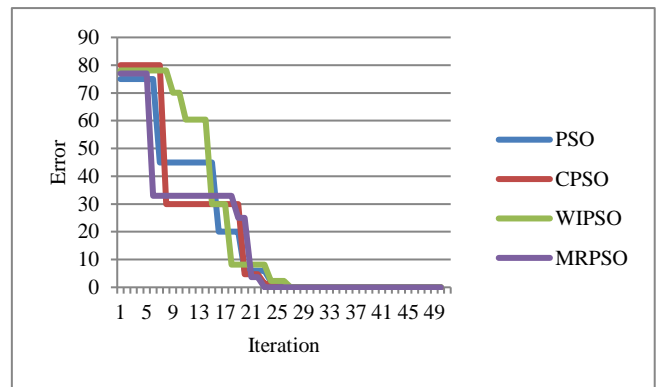


Fig.3: Convergence characteristics of various PSO techniques of six generating unit system.

6. Conclusion

This paper demonstrates three test models of ELD problem and these test data solved by lambda iteration method, PSO, CPSO, WIPSO and MRPSO. The results given in table 2 shows that result of MR-PSO are better than other methods. The cost obtained by MR-PSO for two generating unit is 2511.13\$/h and its take 0.480 second time. Results of 3 generating unit system is obtained by MR-PSO is 8194.201\$/h and time taken by MR-PSO is 0.391 second. Similarly results of 6 generating unit are MR-PSO is 810.51\$/h and computation time taken by MR-PSO is 0.529 second.

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