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A New Approach to Economic Load Dispatch by using Improved QEMA based Particle Swarm Optimization Considering Generator Constraints

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Abstract – *Economic Load Dispatch (ELD) proves to be a vital optimization process in electric power system for allocating generation amongst various units to compute the cost of generation , the cost of emission involving global warming gases like sulphur dioxide, nitrous oxide and carbon monoxide etc. This article proposes a new heuristic for global multi objective optimum dispatch using improved Quantum behaved electro-magnetism algorithm particle swarm optimization (QEMAPSO) algorithm approach. QEMA employs q bit for spinning up and down the states of a particle to specify the position of a charge particle. The resultant force of interaction due to various charge particles is ascertained using the principle of superposition. The particle position is updated using quantum rotation gates and the probability amplitudes of* i^{th} *dimension of* j^{th} *particle and is followed thereby vide a swarm optimization technique for neutralizing the valve point effect and supporting forbidden zones. The results obtained by using QEMA based PSO method for the cost of generation, cost of emission and combined objective function by the proposed method for 6 units IEEE 30 bus test case systems. This research paper tries to show the numerical detailing of Economic load dispatch issue arrangement utilizing delicate registering method in electric era structure considering different physical and power induced system imperatives. This method increases the tendency of particles to venture into the solution space to ameliorate their convergence rates.*

***Key Words*: Economic load dispatch, Equality constraints, In-equality constraints, improved Quantum behaved electromagnetism algorithm, Particle swarm optimization, Genetic Algorithm, Evolutionary Programming, Dance bee colony optimization.**

1. INTRODUCTION

Power system stability is the tendency of a power system to develop restoring forces equal to or greater than the disturbing forces to maintain the state of equilibrium. In this paper, improved QEMA based particle swarm optimization which is one of the computational algorithm technique is applied successfully to solve the problem of economic load dispatch. The objective function considered here is minimization of fuel cost of generators for IEEE 30 bus 6- generating systems used in thermal power plant.

In the current electric power frameworks, there are distinctive creating units e.g. hydro, steam, and biomass and so on. Likewise, the heap request vacillates for the time of a day and achieves diverse pinnacle esteems. In this way, it is basic to settle on which producing unit to off/on and furthermore the request in which the units must be closed down remembering the cost benefit of turning on and stopping. The entire work of figure and making these evaluations is known as load dispatch. The financial load dispatch implies that the generator's yield is permitted to change inside persuaded restrains so that to take care of a specific load demand contained by least fuel cost.

The nonlinear behaviour of input output characteristic of a generator analysed through conventional methods like Lambda iteration method, Gradient method and Newton method etc. does not yield optimal solution with speed and accuracy. So it needs heuristic methods such as Fuzzy Logic, Genetic Algorithm, Neural network, Differential Evolution, and improved Quantum behaved electro-magnetism algorithm based particle swarm optimization [9]etc. to obtain optimal solution for multi- objective generation dispatch[5].QEMA considers charge particles spreading around the solution space to effectively solve the optimization problem in neural network training, Communication, Array pattern optimization, Control system and ELD problems [2]. In this dissertation a single particle manifests several probability states which are further decoded into 2 states using Q bit mechanism that is either an up Q bit or down Q bit. This probability representation together with superposition principle is used to update the particle position which in turn communicates with the solution space to drive better charge particles for meeting out the equality, inequality, valve point and forbidden zone constraints. The solution thus obtained is regarded as the initial position for a swarm optimization technique. The velocity for this position is computed to obtain the best fit global solution for economic load dispatch for meeting out the optimization criteria for ELD. Thus, there is a wide trend of adopting stochastic algorithms which are able to effectively solve the economic dispatch problem. Propitious results have been reported during the past few years and several methods like genetic algorithm (GA) [3], evolutionary programming (EP) [4],Dance bee colony optimization[10] many other methods were successfully implemented in practical ED problems significantly improving the existing results of the problem.

2. PROBELM FORMULATION

The basic ELD problem is formulated in equation (1) and (2) as follows.

$$Z_i = (a_i PG_i^2 + b_i PG_i + C_i) + K_i \sin(l_i(P_i - PG_i)) \quad (1)$$

$$J_i = (h_i PG_i^{\ 2} + g_i PG_i + q_i) \quad (2)$$

Where Z_i and J_i are cost and emission objective functions and a_i, b_i, c_i, K_i, l_i and h_i, g_i, q_i are cost and emission objective function coefficients. It involve combined objective formulation encompassing cost as well as emission objective function vide price penalty factor Pf_i is formulated as (3).

$$S_i = Z_i + Pf_i \times J_i \quad (3)$$

$$Pf_i = Z_{i\max} / J_{i\max} \quad (4)$$

The constraints involved in this work are

(i)Equalityconstraint $\sum_{i=1}^{n} PGi = P_D + TransmissionLoss \quad (5)$ Where P_D = net power demand.

(ii) Inequality constraint

$P_i \langle PG_i \langle P_j \quad (6)$ Where PG_i represents the output power of i^{th} generating unit, P_i and P_j are minimum and maximum output

3. OVER VIEW ON PSO TECHNIQUES

This section describes the proposed Particle Swarm Optimization method. It is an optimization and search technique based on the principles of social behavior of animals. The method was developed in 1995 by James Kennedy and Russell Eberhart [2]. PSO is very good at finding good enough solutions for a large range of problems, such as constrained optimization problems, multi-objective optimization problems, etc.

It is a simple and powerful optimization tool which scatters random particles, i.e., solutions in the problem space. These particles, called swarms collect information from each array constructed by their respective positions. The particles update their positions using the velocity of particles. Position and velocity are both updated in a heuristic manner using guidance from particles' own experience and the experience of its neighbour so obtain position and velocity vectors viz. P_{best} and g_{best} i.e.(P_{1best}, P_{2best} ..... P_{ibest}) and (g_{1best}, g_{2best} ..... g_{ibest}) respectively. The updated values of position and velocity are computed using equation (7) and (8).

$$V_i^{(t+1)} = WV_1(t) + C_1 Rand_1(P_{best} - x_i^t) + C_2 Rand_2(g_{best} - x_i^t)] \quad (7)$$

$$x_i^{t+1} = x_i^t + V_i^{t+1} \quad (8)$$

Where C_1, C_2 are acceleration coefficients

W = Inertia weight

V_i^t = Initial i^{th} particle after t^{th} iteration

V_i^{t+1} = Updated velocity of particle at t+1 iteration

X_i^t = Initial i^{th} particle after t^{th} iteration

X_i^{t+1} = Updated position of particle at t+1 iteration

4. PROPOSED IMPROVED QEMA BASED PSO ALGORITHM

This PSO algorithm is utilized mainly to determine the optimal allocation of power among the committed units, thus minimizing the total generation cost. To implement this PSO algorithm to solve the ELD problems mentioned steps should be described in the following steps.

Step – 1

The Solution obtained from QEMA for cost objective function is
T treated as the initial solution for the PSO based Stochastic Optimization [3].

Step – 2

When the current fitness function L_i becomes better than

P_{best} function L_0 then $L_i = L_{0new}$

Otherwise,

$$L_i = L_{0old}$$

Step Step – 3

Initialize g_{best}

Step – 4

Assign best of new current fitness function and old P_{best}

function to g_{best}

Step – 5

Current position $x_i^t = Z_{iQPSO} + PF_i \times J_{iQPSO}$

Step – 6

Current velocity $V_i^t = U_{i\min} + Randi()(U_{i\max} - U_{i\min})$

The Step – 7

Update the velocity and position for particle $V_i^{(t+1)} = WV_1(t) + C_1Rand_1(P_{best} - x_i^{\,t}) + C_2Rand_2(g_{best} - x_i^{\,t})]$, $x_i^{t+1} = x_i^t + V_i^{t+1}$
where V_i^{t+1}, x_i^{t+1} are the update velocity, update position for each particle.

Step - 8

If Particle position x_i^{t+1} is greater than or equal to bound specified in the valve point effect &forbidden zones then stop otherwise go to step 2[4].

5. RESULT ANALYSIS:

Unit	a_i	b_i	c_i	h_i	g_i	q_i	k_i	l_i	$Pg_{i\min}$	$Pg_{i\max}$	Pg_{inew}
1	0.1421	37.429	755.75	0.0035	0.3244	23.849	290	0.025	15	105	0.2273
2	0.0951	45.141	450.325	0.0038	0.32665	23.849	190	0.032	25	155	0.1838
3	0.0182	39.383	1048.82	0.00672	0.54711	40.270	190	0.032	35	205	0.1395
4	0.0021	37.302	1234.55	0.00102	0.54632	40.2608	140	0.053	45	255	0.0947
5	0.009	35.321	1652.52	0.00500	0.5112	42.8855	140	0.053	65	355	0.0495
6	0.165	37.245	1352.65	0.00502	-0.5138	50.8553	140	0.053	85	455	0.0041

Table(1): Cost coefficients, emission coefficients & other coefficients for 6 power generating units

Unit	Operating Cost For improved QEMA based PSO method in (M$/hr)	Operating Cost For improved QEMA PSO method for Genetic algorithm method in (M$/hr)	Operating Cost For Dance Bee Colony Optimization method in (M$/hr)
1	3.8208	3.9103	3.8014
2	3.8279	3.9002	4.1012
3	3.8285	3.8351	3.8755
4	3.8287	3.9782	4.2105
5	3.8291	4.2112	4.2887
6	3.8288	4.1445	4.3017

Table (2): Performance Comparison for operating cost Objective Functions for generating units

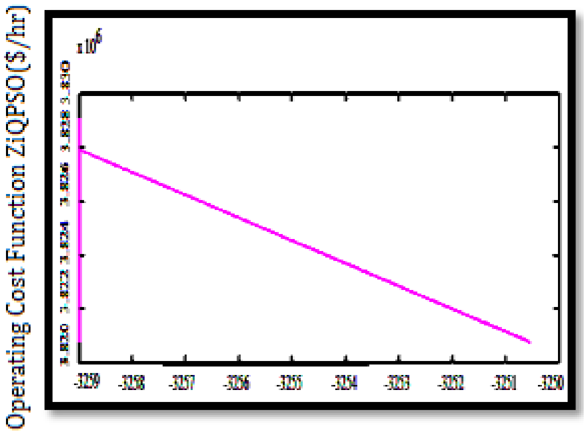
Unit	Emission level for improved QEMA based PSO method in ($T/hr\times10^5$)	Emission level for improved QEMA PSO method for Genetic algorithm in ($T/hr\times10^5$)	Emission level for For Dance Bee Colony Optimization method in ($T/hr\times10^5$)
1	2.7075	2.8021	2.921
2	2.708	2.825	2.962
3	2.7085	2.8084	2.989
4	2.709	2.812	2.941
5	2.7095	2.8096	2.811
6	2.71	2.79	2.97

Table (3): Performance Comparasion for Emission Level for generating units

Unit	Combined Objective Cost for improved QEMA based PSO method in (M$/hr)	Combined Objective Cost for Genetic algorithm method in (M$/hr)	Combined Objective Cost for Dance Bee Colony Optimization method in (M$/hr)
1	3.4	3.23	3.71
2	3.5	3.46	3.83
3	3.6	3.58	3.91
4	3.7	3.64	3.96
5	3.8	3.74	4.14
6	3.9	4.11	4.23

Table (4): Performance Comparison for combined Objectives for generating units

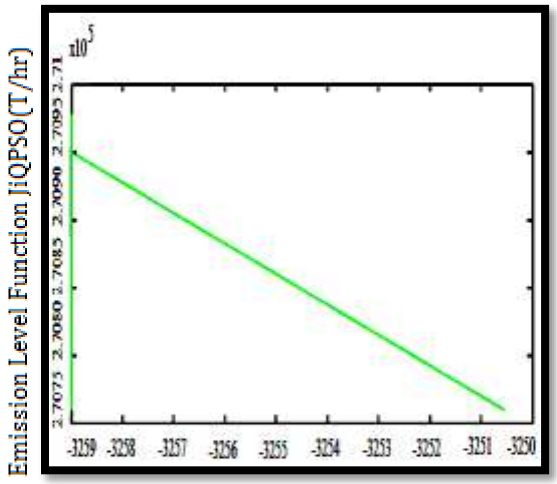
RESULTS AND DISCUSSION:



Output Power Pg_i (MW)

(Number of Iterations = 50)

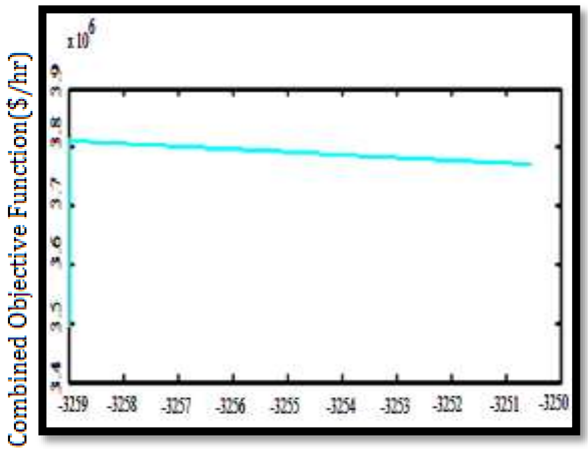
Fig.1 Operating cost function $ZiQPSO$ Vs. Real power Pg_i



Output Power Pg_i (MW)

(Number of Iterations = 50)

Fig.2 Emission level function $JiQPSO$ Vs.Real power Pg_i



Output Power Pg_i (MW)

(Number of Iterations = 50

Fig.3 Combined objective function $SiQPSO$ Vs. Real power Pg_i

The above various objective functions are analysed by writing programmes in MATLAB software.

4. COMPARASION OF RESULT ANALYSIS BASED ON IMPROVED QEMA PSO

Based on 50 numbers of iterations an improved QEMA based PSO cost objective function shows that the optimum amount of real power generation with minimize fuel cost, this PSO based emission level function is slightly decreasing & this PSO based combined objective function is slightly increasing. These results are compared with the results available in literature for 6- generator, IEEE 30 bus system and it is found that results are significantly improved by the proposed algorithm.

A review on ramp rate and constriction factor based PSO is presented in H.S.M a h a r a n a and S. K. Dash [1].All these methods were simulated using Mat lab software with the options given in Table(2), Table(3) and Table(4) respectively. Note that all improved QEMA based PSO performed in each of the three problems that illustrate the result vide Fig.1, Fig.2 and Fig.3 showing the variation of operating cost function(Z i Q P S O), emission level function (J i Q P SO) and Combined l objective function (S i Q PSO)[10],yields better optimal solution.

6. CONCLUSIONS

Tuning of various parameters of improved QEMA based PSO [8] is important and it is found that the values of parameters in this paper are perfect for the improvement of results. The results demonstrate that this PSO out performs other methods, particularly for non-convex cases, in terms of solution quality, dynamic convergence, computational efficiency, robustness and stability. The proposed algorithm can also be applied to other power system optimization problems like dynamic economic dispatch and reactive power dispatch. The proposed method presented advanced PSO technique involving valve point loading, ramp rate constraints, constriction factor based swarm optimization [1] tool box for analysing the economic dispatch problem. The results of this analysis outperform classical methods like lambda iteration method, mixed integer linear programming method quadratic programming method etc. and heuristic methods like particle swarm optimization, weight improved particle swarm optimization, dispersed particle swarm optimization, Genetic Algorithm[6],[7] etc. in terms of computational time for better optimal solution.

An improved QEMA based PSO deals with personal experience of agents in going from personal best to global best so it effectively deals with POZ in electric power system and yields thereby optimum operating cost for multi-objective Economic Load Dispatch problem.

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BIOGRAPHIES

Himanshu Shekhar Maharana completed his B. Tech degree in EEE from JITM, Paralakemundi under BPUT, Rourkela, Odisha in 2010 and Completed M. Tech degree in Power System Engineering from GITA, Bhubaneswar BPUT, Rourkela, Odisha in the year 2014. At present he is continuing full time Ph.D. under the guidance of professor Dr. Saroj Kumar Dash in BPUT, Rourkela, Odisha. He has awarded with best research paper during his Ph.D work i.e. "Ramp Rate and Constriction Factor Based Dual Objective Economic Load Dispatch Using Particle Swarm Optimization", International Journal of Energy and Power Engineering, Volume: 11, No: 6, Pp.636 - 640 in ICEESAO conference, World Academy of Science, Engineering and Technology, San Francisco, USA during 7th -8th, June 2017.

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