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Application of Gravitational Search Algorithm for Real Power Loss and Voltage Deviation Optimization

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Abstract*— Reactive power flow in a power system is optimized by real power loss minimization and it is essential for secured operation of power systems with regard to voltage stability and it also improves the economics of power system operation. Generator bus voltage magnitude, transformer tap settings and SVC controllers are the control variables for reactive power flow optimization. In this paper, the nature inspired gravitational search algorithm (GSA) is introduced to solve a multi constrained optimal reactive power flow problem in power systems. The algorithm is a recent development in the area of nature inspired algorithms for global optimization. The performance of the GSA based algorithm is tested on standard IEEE 30 bus test system and the results are compared with other methods to prove the effectiveness of the new algorithm. The results are quite encouraging and the algorithm is found to be suitable for power system operation optimization.

***Keywords*-Gravitational Search Algorithm, Optimal Reactive Power Dispatch, Loss Minimization, Voltage Deviation Minimization.**

I. INTRODUCTION

The increased demand for electric power and the insufficient power generation and transmission facility forces the power system networks being operated under stressed conditions. The security of a power system is under threat when it is operated at stressed conditions and may result in voltage instability. Insufficient reactive power availability or non-optimized reactive power flow may lead a power system to insecure operation under heavily loaded conditions [1]-[2]. By reallocating reactive power generations in the system by adjusting transformer taps, generator voltages and switchable VAR sources, the problem can be solved to a far extent.

Apart from the aforementioned methods, the system losses can also be minimized via re-distribution of reactive power in the system for improving the stability of a power system. Large amount of reactive power flow in a system is indicated by the real power loss in the system. Therefore minimizing the real power loss ensures optimized reactive power flow (ORPF) through the lines. Reactive power optimization by real power loss minimization increases the power system economics to some considerable extent. Reactive power optimization by minimization of real power loss has long been attempted for voltage stability improvement in a number of research works [3]-[4].

ORPF is an important tool in terms of secure and operation of power system. It is a powerful concept for power system operation and planning [5]-[6]. In ORPF, the network active power loss is reduced and voltage profile is improved while satisfying a given set of operating and physical constraints [7]-[8]. Reactive power flow is optimized by properly setting the values of control parameters. A number of conventional optimization methods have been exploited for this objective. Techniques such as non linear programming technique [9], gradient based optimization algorithm are used to solve ORPF problem algorithms [10] are used to solve ORPF problem. But it has several disadvantages like large numerical iteration, insufficient convergence properties; which leads to large computation and more execution time.

The recently developed meta-heuristics based algorithms are proving better performance than the conventional methods. They find global best or nearly global best solutions in engineering problems. These algorithms are better utilized for power system optimization. Some of them are Tabu Search (TS) [11], Simulated Annealing (SA) [12], Genetic Algorithm (GA) [13], Evolutionary Programming (EP) [14]-[15] Hybrid Evolutionary Programming (HEP) [16], Particle Swarm Optimization PSO [17]-[19], Chaotic Ant Swarm Optimization (CASO) [20], Bacterial Foraging Optimization (BFO) [21], Ant Colony Optimization (ACO) [22], Differential Evolution (DE) [23] and Quantum Genetic Algorithm (QGA) [24] are developed which provides fast and optimal solution. Conventional methods are sensitive to initial guess of the search point where functions have multiple local minima and not efficient in handling problems of discrete variables [25]. Recently, Bansilal proposed a system for limiting voltage variations by means of switchable shunt reactive compensation and transformer tap setting [26]. Other new optimization techniques are based on using fuzzy logic [27] and Lagrangian decomposition method [28].

Gravitational search algorithm (GSA) algorithm is a recent development and it is very simple and easy to implement [29]-[30]. This algorithm has less number of parameters and has good convergence characteristics. In this paper, the GSA method is used for ORPD problem. The performance of this method is compared with other algorithms to prove its efficiency. This technique compares the quality of solution and gives near global optimal solution.

II. PROBLEM FORMULATION

The objective of this work is to optimize the reactive power flow in a power system by minimizing the real power loss and sum of load bus voltage deviations. An augmented objective function is formed with the two objective components and weights.

A Objective Function

The objective function of this work is to find the optimal settings of reactive power control variables including the rating shunt var compensating devices which minimizes the real power loss and voltage deviation. Hence, the objective function can be expressed as:

$$f = min\{w P_L + (1-w) VD\} \qquad (1)$$

Where w is the weighing factor for real power loss and voltage deviation and is set to 0.7.

1 Real power loss minimization (P_L)

The total real power of the system can be calculated as follows

$$P_L = \sum_{k=1}^{N_L} G_k [V_i^2 + V_j^2 - 2V_iV_j\cos(\delta_i - \delta_j)] \qquad (2)$$

Where , N_L is the total number of lines in the system; G_k is the conductance of the line ‘k’; V_i and V_j are the magnitudes of the sending end and receiving end voltages of the line; δ_i and δ_j are angles of the end voltages.

2 Load bus voltage deviation minimization (VD)

Bus voltage magnitude should be maintained within the allowable range to ensure quality service. Voltage profile is improved by minimizing the deviation of the load bus voltage from the reference value (it is taken as 1.0 p.u. in this work).

$$VD = \sum_{k=1}^{N_{PQ}} |(V_k - V_{ref})| \qquad (3)$$

B Constraints

The minimization problem is subject to the following equality and inequality constraints

1 Equality constraints:

Load Flow Constraints:

$$P_{Gi} - P_{Di} - \sum_{j=1}^{N_B} V_i V_{ij} Y_{ij} \cos\left(\delta_{ij} + \gamma_j - \gamma_i\right) = 0 \qquad (4)$$

$$Q_{Gi} - Q_{Di} - \sum_{j=1}^{N_B} V_i V_{ij} Y_{ij} \sin\left(\delta_{ij} + \gamma_j - \gamma_i\right) = 0 \qquad (5)$$

2. Inequality Constraints:
Reactive Power Generation Limit of SVCs:

$$Q_{ci}^{min} \leq Q_{ci} \leq Q_{ci}^{max}; i \in N_{SVC} \qquad (6)$$

Voltage Constraints:

$$V_i^{min} \leq V_i \leq V_i^{max}; i \in N_B \qquad (7)$$

Transmission line flow limit:

$$S_i \leq S_i^{max}; i \in N_l \qquad (8)$$

Tap position Constraints:

$$T_{Pi}^{min} \leq T_{Pi} \leq T_{Pi}^{max}; i \in N_T \qquad (9)$$

III. GRAVITATIONAL SEARCH ALGORITHM

A Overview

Gravitational Search Algorithm is a population based search algorithm based on the law of gravity and mass interaction. The algorithm considers agents as objects consisting of different masses. The entire agents move due to the gravitational attraction force acting between them and the progress of the algorithm directs the movements of all agents globally towards the agents with heavier masses. Each agent in GSA is specified by four parameters [29]-[30]: Position of the mass in d^{th} dimension, inertia mass, active gravitational mass and passive gravitational mass.

The positions of the mass of an agent at specified dimensions represent a solution of the problem and the inertia mass of an agent reflect its resistance to make its movement slow. Both the gravitational mass and the inertial mass, which control the velocity of an agent in specified dimension, are computed by fitness evolution of the problem. The positions of the agents in specified dimensions (solutions) are updated in every iteration and the best fitness along with its corresponding agent is recorded. The termination condition of the algorithm is defined by a fixed amount of iterations, reaching which the algorithm automatically terminates. After termination of the algorithm, the recorded best fitness at final iteration becomes the global fitness for a particular problem and the positions of the mass at specified dimensions of the corresponding agent becomes the global solution of that problem. The algorithm can be summarized as below:

Step 1: Initialization of the agents:

Initialize the positions of the *N* number of agents randomly within the given search interval as below:

$$X_i = \left(x_i^1 \ldots x_i^d \ldots x_i^n\right) \quad for \quad i = 1,2,3 \ldots\ldots N \qquad (10)$$

Where, *N* is the space dimension of the problem and x_i^d defines the position of the i_{th} agent in the d_{th} dimension. Initially, the agents of the solution are defined randomly and according to Newton gravitation theory.

Step 2: Fitness evolution and best fitness computation for each agents:

Perform the fitness evolution for all agents at each iteration and also compute the *best* and *worst* fitness at each iteration defined as below:

For a minimization problem:

$$best(t) = \min_{j \in \{1,\ldots,m\}} fit_j(t) \qquad (11)$$

$$worst(t) = \max_{j \in \{1,\ldots,m\}} fit_j(t) \qquad (12)$$

For a maximization problem:

$$best(t) = \max_{j \in \{1,\ldots,m\}} fit_j(t) \qquad (13)$$

$$worst(t) = \min_{j\in\{1,\ldots m\}} fit_j(t) \qquad (14)$$

Step 3: Computation of gravitational constant G:
Compute gravitational constant G at iteration t using the following equation:

$$G(t) = G_0 e^{\alpha t/T} \qquad (15)$$

In this problem, G_0 is set to 200, α is set to 10 and T is the total number of iterations.
Step 4: Calculate the mass of the agents:
Calculate gravitational and inertia masses for each agents at iteration t by the following equations:

$$M_{ai} = M_{pi} = M_{ii} = M_i, \quad i = 1,2\ldots N$$

$$m_i(t) = \frac{fit_i(t) - worst(t)}{best(t) - worst(t)} \qquad (16)$$

$$M_i(t) = \frac{m_i(t)}{\sum_{j=1}^{N} m_j(t)} \qquad (17)$$

where, M_{ai} is the active gravitational mass of the i^{th} agent , M_{pi} is the passive gravitational mass of the i^{th} agent, M_{ii} is the inertia mass of the i^{th} agent.
Step 5: Calculate accelerations of the agents:
Compute the acceleration of the i^{th} agents at iteration t as below:

$$a_i^d(t) = \frac{F_i^d(t)}{M_{ii}(t)} \qquad (18)$$

Where $F_i^d(t)$ is the force on i^{th} agent in d^{th} dimension as given in the following equation.

$$F_i^d(t) = \sum_{j\in kbest. j\neq i}^{N} rand_j F_{ij}^d(t) \qquad (19)$$

k_{best} is the set of first k agents with the best fitness value and biggest mass. k_{best} is computed in such a manner that it decreases linearly with time and at last iteration the value of k_{best} becomes 2% of the initial number of agents. $F_{ij}^d(t)$ is the force acting on agent `i' from agent `j' at d^{th} dimension and t^{th} iteration is computed as below:

$$F_{ij}^d(t) = G(t)\frac{M_i(t) \times M_j(t)}{R_{ij}(t) + \varepsilon}\left(x_j^d(t) - x_i^d(t)\right) \qquad (20)$$

where, $R_{ij}(t)$ is the Euclidian distance between two agents `i' and `j' at iteration t and $G(t)$ is the computed gravitational constant at the same iteration. ε is a small constant.
Step 6: Update velocity and positions of the agents:
Compute velocity and the position of the agents at next iteration (t + 1) using the following equations:

$$V_i^d(t+1) = rand_i \times V_i^d(t) + a_i^d(t) \qquad (21)$$

$$X_i^d(t+1) = X_i^d(t) + V_i^d(t+1) \qquad (22)$$

Step 7: Repeat from Steps 2-6 until iterations reaches their maximum limit. Return the best fitness computed at final iteration as a global fitness of the problem and the positions of the corresponding agent at specified dimensions as the global solution of that problem.

B Implementation of Gravitational Search Algorithm to the OPF problem:

Step 1: Form an initial generation of N candidates in a random manner respecting the limits of search space as [V_{Gi}, T_{Pi}, Q_{SVCi}].

Step 2: Calculate the fitness function values of all candidate solution by running the NR load flow.

Step 3: Update $G(t)$, $best(t)$, $worst(t)$ and $M_i(t)$ for $i = 1, 2, \ldots, N$.

Step 4: Calculation of the total force in different directions, acceleration and velocity.

Step 5: Return to step 2 until stopping criteria has not been achieved.

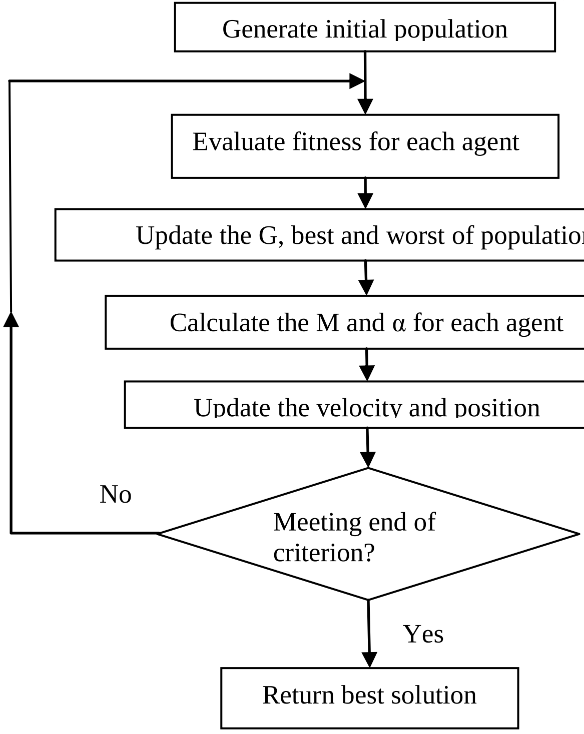

Fig 1. Flow chart for GSA algorithm

IV. NUMERICAL RESULTS AND DISCURSION

The performance of the proposed GSA algorithm based reactive power optimization method is tested in the medium size IEEE 30 bus system. The algorithm is coded in MATLAB environment and a Core 2 Duo, 2.8 MHz, 2GB RAM based PC is for the simulation purpose.

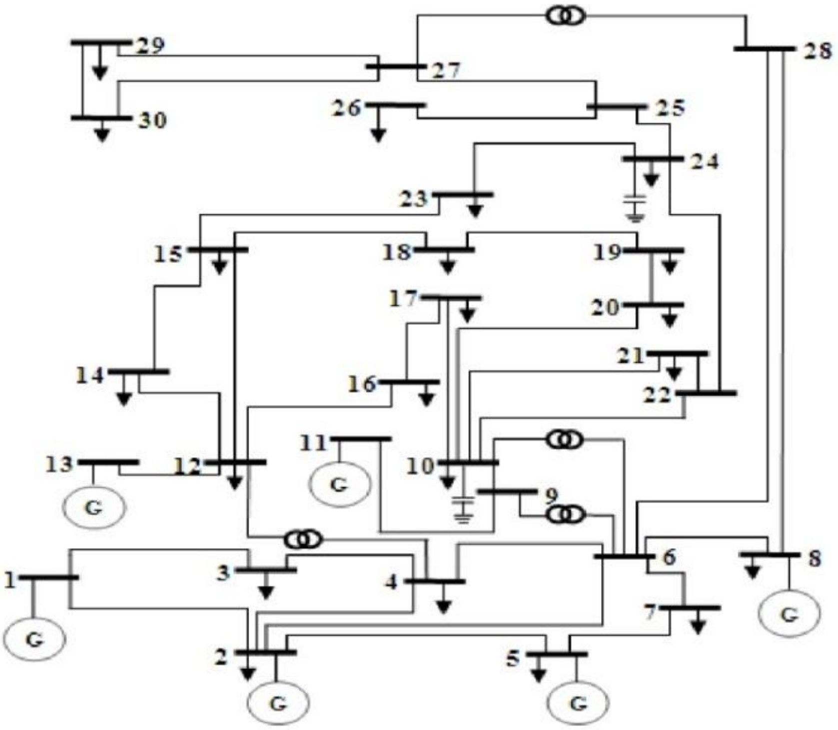

Fig 2. Single Line Diagram of IEEE-30 Bus System

The test system taken has six generating units connected to buses 1,2,5,8,11 and 13. There are 4 regulating transformers connected between bus numbers 6-9, 6-10, 4-12 and 27-28. Two shunt compensators are connected in bus numbers 10 and 24. The system is interconnected by 41 transmission lines. The control variables are generator's voltages, tap settings of the regulating transformers and var injection of shunt capacitors. The upper and lower bounds of the different control variables are given in table 1.

Table 1. Control variable limits

Sl No	Control Variable	Limit
1	Generator voltage (V_G)	(0.9-1.1) p.u.
2	Tap setting (T_P)	(0.9)- (1.1) p.u.
3	MVAR by static compensators (Q_{svc})	(0-10)

For reactive power optimization, the control parameters are adjusted that the objective function value is minimum. The approach of minimizing both real power loss and voltage minimization is most suitable one for reactive power optimization as all the indicators of reactive power optimization is included. The optimal value of control parameters for this case is tabulated below as table 2.

Table 2. Optimal parameter settings

Sl No	Parameter	Initial value	Optimal Value
1	V_{G1}	1.05	1.0971
2	V_{G2}	1.04	1.0888
3	V_{G5}	1.01	1.0669
4	V_{G8}	1.01	1.0683
5	V_{G11}	1.05	1.0775
6	V_{G13}	1.05	1.0416
7	T_{6-9}	1.078	1.0360
8	T_{6-10}	1.069	1.0450
9	T_{4-12}	1.032	1.0396
10	T_{27-28}	1.068	1.0136
11	Q_{10}	0.0	8.1709
12	Q_{24}	0.0	3.0393

The loss minimization performance of GSA is better than that of BBO reported in [1]. The percentage loss reduction is level is from 5.7440 MW to 4.8210 MW. It is obvious from table 3, that BBO reduces the loss level to only 5.632 MW.

Table 3. Minimization of objective function terms

Sl. No	Parameter	Initial value	BBO [1]	GSA
1	P_{loss}	5.7440	5.63200	4.8210
2	VD	1.4753	0.15499	0.5366

Convergence of GSA when handling augmented objective function is superior as given in figure 3. The algorithm converges in a better manner for different objectives and it proves the reliability of the algorithm. The algorithm takes less number of iterations and maintains the global best results.

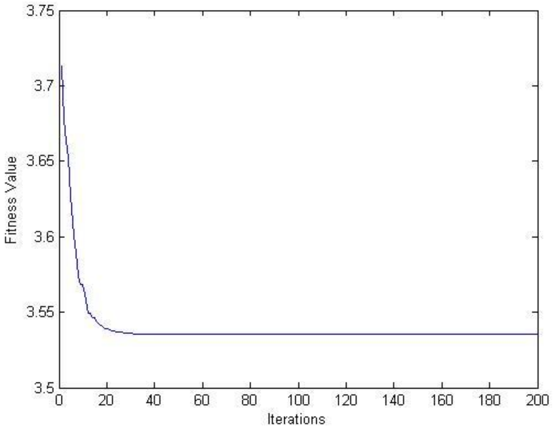

Fig 3. Convergence Characteristics of GSA

For clear understanding of the improvement in voltage profile, the p.u. voltage magnitude of all the buses in the system before and after the implementation the algorithm are compared in figure 4. It clear from the figure, that most of the load bus voltages are equal to about 1.0 p.u.

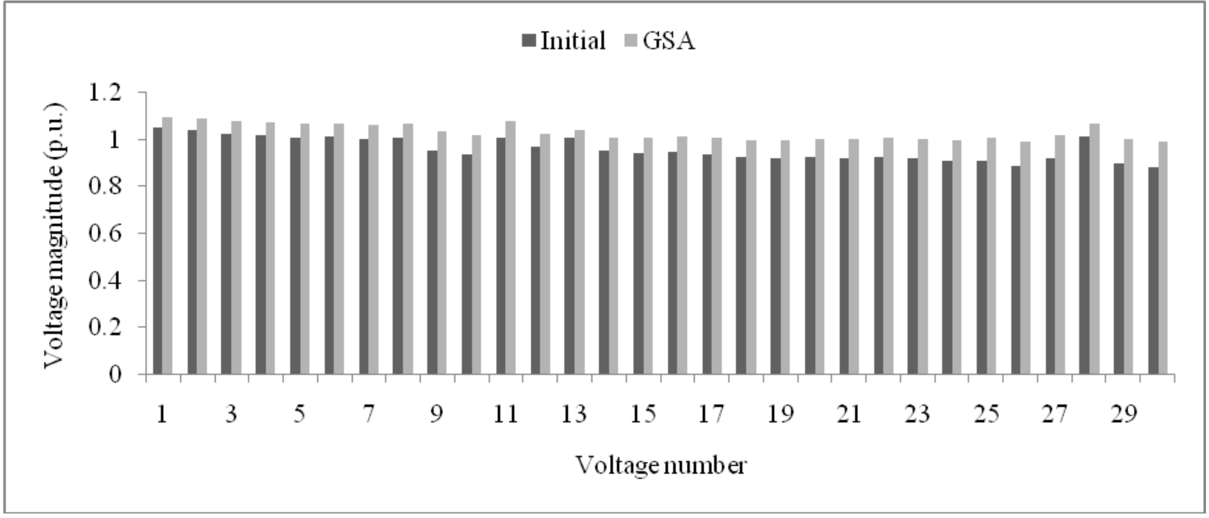

Fig 4. Voltage profile improvement

V. CONCLUSION

In this paper, a nature inspired GSA optimization algorithm is proposed to solve multi-objective optimal reactive power flow problem. The performance of the proposed algorithm for solving ORPF problems is demonstrated using IEEE-30 bus system. The results are compared to those of other algorithms like PSO and BBO. The test results clearly demonstrate that GSA outperforms other reported methods in terms of solution quality. The superiority of the proposed GSA method is more pronounced for large system as is evident from IEEE-30 bus system. From all simulation results it may finally be concluded that among all the three algorithms, GSA based optimization method is capable of achieving global optimal solution. This paper shows that such excellent results with different objective functions shows that makes the proposed GSA optimization technique is good in dealing with power system optimization problems.

REFERENCES

[1] P.K. Roy , S.P. Ghoshal , S.S. Thakur, “Optimal VAR Control for Improvements in Voltage Profiles and for Real Power Loss Minimization using Biogeography Based Optimization”, Electrical Power and Energy Systems, Vol. 43, No.1, pp. 830–838, December 2012.

[2] Abbas Rabiee, Maziar Vanouni, Mostafa Parniani, “Optimal Reactive Power Dispatch for Improving Voltage Stability Margin Using a Local Voltage Stability Index”, Energy Conversion and Management, Vol. 59, pp. 66-73, July 2012.

[3] Kursat Ayan, Ulas kilic, “Artificial Bee Colony Algorithm Solution for Optimal Reactive Power Flow”, Applied Soft Computing, Vol.12, No. 5, pp. 1477–1482, May 2012.

[4] M. Varadarajan, K.S. Swarup, “Differential Evolutionary Algorithm for Optimal Reactive Power Dispatch, Electrical Power & Energy Systems, Vol. 30, No. 8, pp. 435–441, October 2008.

[5] Amit Saraswat, Ashish Saini, “Multi-Objective Optimal Reactive Power Dispatch Considering Voltage Stability in Power Systems using HFMOEA”, Engineering Applications of Artificial Intelligence, Available online 18 July 2012.

[6] Altaf Q.H. Badar , B.S. Umre, A.S. Junghare, “Reactive Power Control Using Dynamic Particle Swarm Optimization for Real Power Loss Minimization”, Electrical Power & Energy Systems, Vol. 41, No. 1, pp. 133–136, October 2012.

[7] Reza Sirjani , Azah Mohamed, Hussain Shareef, “Optimal Allocation of Shunt Var Compensators in Power Systems Using a Novel Global Harmony Search Algorithm”, Electrical Power & Energy Systems, Vol. 43, No.1, pp. 562–572, December 2012.

[8] Serhat Duman , Ugur Guvenc , Yusuf Sonmez , Nuran Yorukeren, “Optimal Power Flow Using Gravitational Search Algorithm”, Energy Conversion and Management, Vol. 59, pp.86–95, July 2012.

[9] Mansour MO, Abdel-Rahman TM, “Non-linear VAR Optimization Using Decomposition and Coordination”, IEEE Transactions on Power Apparatus Systems Vol. PAS-103, No. 2, pp. 246–55, February 1984.

[10] Mamandur KRC, Chenoweth RD, “Optimal Control of Reactive Power Flow for Improvements in Voltage Profiles and for Real Power Loss Minimization”, IEEE Transactions on Power Apparatus Systems, Vol. PAS-100, No.7, pp. 3185–3193, July 1981.

[11] Gan D, Qu Z, Cai H, “Large-Scale VAR Optimization and Planning by Tabu Search”, Electric Power Systems Research, Vol. 39, No. 3, pp. 195–204, December 1996.

[12] Hsiao YT, Chiang HD, “Applying Network Window Schema and a Simulated Annealing Technique to Optimal VAR Planning in Large-Scale Power Systems”, Electric Power Systems Research,Vol. 22, No. 1, pp.1–8, January 2000.

[13] Iba K. “Reactive Power Optimization by Genetic Algorithm”, IEEE Transactions on Power Systems, Vol.9, No. 2, pp. 685–692, May 1994.

[14] Lai LL, Ma JT, “Application of Evolutionary Programming to Reactive Power Planning-Comparison with Nonlinear Programming Approach”, IEEE Transactions on Power Systems, Vol.12, No.1, pp.198–206, February 1997.

[15] Abido MA, Bakhashwain JM, “Optimal VAR Dispatch Using a Multi Objective Evolutionary Algorithm, Electric Power & Energy Systems,Vol.27, No. 1, pp.13–20, January 2005.

[16] Swain AK, Morris AK, “A Novel Hybrid Evolutionary Programming Method for Function Optimization. In: Proc 2000 Congress on Evolutionary Computation, Vol. 1, pp. 699–705, 2000.

[17] Yoshida H, Kawata K, Fukuyama Y, Takayama S, Nakanishi Y, “A Particle Swarm Optimization for Reactive Power and Voltage Control Considering Voltage Security Assessment”, IEEE Transactions on Power Systems, Vol.15, No.4, pp, 1232–1239, November 2000.

[18] Esmin AAA, Lambert-Torres G, de Souza ACZ, “A Hybrid Particle Swarm Optimization Applied to Power Loss Minimization”, IEEE Transactions on Power Systems, Vol. 20, No. 2, pp 859–866, May 2005.

[19] Roy Ranjit, Ghoshal SP, “A Novel Crazy Swarm Optimized Economic Load Dispatch for Various Types of Cost Functions”, Electric Power & Energy Systems, Vol. 30, No. 4 , pp. 242–253, May 2008.

[20] Cai J, Mab X, Li Q, Li L, Peng H, “A Multi-Objective Chaotic Ant Swarm Optimization for environmental/Economic Dispatch”, Electric Power & Energy Systems, Vol.32, No.5, pp. 337–344, June 2010.

[21] Ghoshal SP, Chatterjee A, Mukherjee V, “Bio-Inspired Fuzzy Logic based Tuning of Power System Stabilizer”, Expert Systems with Applications, Vol. 36, No. 5, pp. 9281–9292, July 2009.

[22] Pothiya S, Ngamroo I, Kongprawechnon W, “Ant Colony Optimisation for Economic Dispatch Problem with Non-smooth Cost Functions”, Electric Power & Energy Systems, Vol. 32, No. 5, pp 478–487, June 2010.

[23] Shaheen HI, Rashed GI, Cheng SJ, “Optimal Location and Parameter Setting of UPFC for Enhancing Power System Security based on Differential Evolution Algorithm”, Electric Power & Energy Systems, Vol. 33, No.1, pp. 94–105, Jan 2011.

[24] Lee JC, Lin WM, Liao GC, Tsao TP, “Quantum Genetic Algorithm for Dynamic Economic Dispatch with Valve-Point Effects and Including Wind Power System,” Electric Power &Energy Systems, Vol. 33, No. 2, pp. 189–197, February 2011.

[25] R. Mallipeddi , S. Jeyadevi , P.N. Suganthan , S. Baskar, “Efficient Constraint Handling for Optimal Reactive Power Dispatch Problems”, Swarm and Evolutionary Computation, Vol.5, pp. 28–36, August 2012.

[26] Chien-Feng Yang , Gordon G. Lai , Chia-Hau Lee , Ching-Tzong Su , Gary W. Chang, “Optimal Setting of Reactive Compensation Devices with an Improved Voltage Stability Index for Voltage Stability Enhancement”, Electric Power & Energy Systems, Vol. 37, No.1, pp. 50–57, May 2012.

[27] Reza Taghavi, Ali Reza Seifi , Meisam Pourahmadi-Nakhli, “Fuzzy Reactive Power Optimization in Hybrid Power Systems”, Electric Power & Energy Systems, Vol. 42, No.1, pp. 375–383, November 2012.

[28] M. Granadaa, Marcos J. Riderb, J.R.S. Mantovani, M. Shahidehpour, “A Decentralized Approach for Optimal Reactive Power Dispatch Using a Lagrangian Decomposition Method”, Electric Power Systems Research, Vol. 89, pp. 148– 156, August 2012.

[29] Rashedi E, Rashedi E, Nezamabadi-pour H, Saryazdi, “GSA: A Gravitational Search Algorithm”, Information Sciences, Vol.179, No. 13, pp. 2232–2248, June 2009.

[30] Duman S, Guvenc U, Yorukeren N, “Gravitational Search Algorithm for Economic Dispatch with Valve-Point Effects”, International Review of Electrical Engineering, Vol. 5, No. 6, pp. 2890–2895, November-December 2010.

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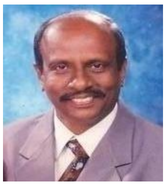

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