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Generator Rescheduling for Congestion Management Using Natural Exponent Inertia Weight PSO

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Abstract

Line overloading or congestion may occur in transmission line due to unplanned transactions of power. In deregulated electricity market environment problem of congestion is more frequently occurs overloading of a particular line may take place due to profitable market strategies. To relieve the lines from congestion appropriate congestion management strategy needs to be adopted within the system constraints. Congestion management (CM) is a combined effort of congestion relief and its associated price minimization. Rescheduling of generator is a prominent way to relieve the line from transmission line overloading. For managing congestion load shedding and generator rescheduling are the solutions out of which later one is more feasible for reliability point of view. In this paper transmission congestion is managed by optimal rescheduling of generators is formulated as objective function and solved using standard Particle Swarm Optimization (PSO), Natural Exponent Inertia Weight Strategy (e1-PSO) and Natural Exponent Inertia Weight Strategy (e2 -PSO) on six bus test system. The results obtained are compared to demonstrate the better efficiency of improved PSO strategy.

Index Terms— Congestion Management, Particle Swarm Optimization, Natural Exponent Inertia Weight Particle Swarm Optimization. Generator Rescheduling.

I. INTRODUCTION

Transmission lines in power system network operate close or beyond their thermal limits are said to be congested. In deregulated electricity markets the problem is more likely to occur due to unplanned power exchanges. Congestion is managed mainly either by generator rescheduling or by load shedding. In load shedding reliability of power supply gets affected so re-dispatching the output of generator is better option to manage congestion while ensuring the system reliability. In generator rescheduling or re-dispatching independent system operators reschedule the generator output so that congestion has gotten rid off. In this operation ISO commands the generator of low price area to lower down it's output while purchasing power from high price areas this will lead to an additional cost known as rescheduling cost. As rescheduling of generators incurs additional investment an appropriate CM strategy should be adopted that involve minimum cost of generator rescheduling. S. Charles Raja and B. V. Manikandan [2] used PSO is to solve multi-objective problem formulation for CM. Generator rescheduling is formulated as an optimization problem with the objective of obtaining minimum rescheduling cost generators. Manoj Kumar Maharana and K. Shanti Swarup [12] adopted PSO to determine the optimal set of generators so as to minimize the total cost of generation. Direct acyclic graph technique is presented for identification of participating generators and buses with respect to a contingency. Sujatha Balaraman and N. kamaraj [4] implemented differential evolution and PSO algorithm for the solution of nonlinear optimization problem of CM. The problem formulation gives objective function which minimizes the total cost incurred for adjusting real power generation of the participating generators. B. V. Manikandan et al. [20] gives comparison between cluster/zone method and relative electrical distance (RED) method for CM. In cluster/zone method generators in the most sensitive zone are considered for rescheduling if congestion exists even after rescheduling of generators load curtailment if done for this, PSO is implemented as solution algorithm in this method. Masoud Mohammad Rahimi Fard and Aref Jalili Irani [14] presented a PSO based CM technique where objective is to remove line congestion and increase social welfare with a objective function consisting total production cost of active and reactive power and then total cost of congestion which are to be minimized by optimal placement of UPFC. O. Abedinia et al. [15] implemented vector evaluated particle swarm optimization (VEPSO) to solve CM optimization problem in electricity market. The objective function is to minimize generator re-dispatch cost and constraints considered are power balance constraint, Operating limit constraints and line flow constraints. The generators to participate in CM are selected on the basis of their sensitivities further a comparison is made between various versions of PSO which include. Particle Swarm Optimization (CPSO), PSO with time variant inertia weight (PSOTVIW), PSO with time variant acceleration coefficient (PSOTVAC) and vector evaluated particle swarm optimization (VEPSO). Jagabondhu Hazra and Avinash K. Sinha [2] proposed a multi-objective CM technique using PSO algorithm to solve the complex nonlinear optimization problem with smooth and non-smooth fitness functions. In this paper two conflicting objectives congestion and cost are simultaneously minimized. At first stage generator rescheduling is done and if generator rescheduling alone is not sufficient load shedding is done as a last option to remove congestion. This method also provides a set of pareto optimal solutions for any congestion problem, which provides system operator the alternate course of action to manage congestion. In this paper various CM techniques in the reported literature has been discussed and a novel technique of congestion management is given with minimization of rescheduling cost of generator using standard PSO, Natural Exponent Inertia Weight strategy (e1-PSO) and (e2-PSO) due to better convergence and less computation time of these techniques. Proposed technique is implemented on six bus test system [21] with one line congested. Further results are compared to prove the superiority of proposed technique over other versions.

II. PROBLEM FORMULATION

Problem formulation for managing congestion includes formulation of objective function and constraints. Cost of rescheduling of generators is taken as objective function (1) where $C_g(\Delta P_g)$ is the incremental or decremental bid cost function for each generator, while generator operating limits and MVA flow limits are formulated as constraints. MVA flow constraint is formulated (1) to ensure the flows within the operating limits, Generator outputs are maintained within the limits shown in (3).

Objective Function

$$\text{Minimize} \sum_{g}^{Ng} C_g(\Delta P_g)\Delta P_g \tag{1}$$

Subject to

$$\sum_{g}^{Ng}((GS_g)\Delta P_g) + F_k^o \leq F_k^{max}(2)$$

$$P_g^{min} \leq P_g \leq P_g^{max}(3) \tag{3}$$

$$P_g - P_g^{min} = \Delta P_g^{min} \leq \Delta P_g \leq \Delta P_g^{max}$$
$$= P_g^{max} - P_g \tag{4}$$

where

Δ Pg Real power adjustment at bus-g

Cg Incremental and decremented price bids submitted by generators. These are the prices at which the generators are willing to adjust their real power outputs.

F_k^o	Power flow caused by all contracts requesting the transmission service.
F_k^{max}	Line flow limit of the line connecting bus-i and bus-j
Ng	Number of participating generators
N_l	No. of transmission lines in the system
Pgmin & Pgmax	Minimum and maximum limits of generator outputs.

III. PARTICLE SWARM OPTIMIZATION:

PSO is a combinatorial meta-heuristic optimization technique first introduced by Kennedy and Eberhart[1] in mid 1990. PSO has advantage of better convergence with lesser number of algorithm parameters over other optimization techniques like Evolutionary programming, Differential Algorithm, Genetic Algorithm etc. The algorithm is motivated by behavior of social organisms such as bird flocking or fish schooling. . PSO is a population based search technique. Each individual potential solution in PSO is called particle. Each particle in a swarm flies around in a multidimensional search space based on its own experience and experience of neighboring particles. PSO combines self-experiences with social experiences. Let an n dimensional search space S with N no. of particles. Let at an instant t, particle i have its position defined by X_t^i and velocity by V_t^i space S. Velocity and position of each particle in the next generation can be calculated as.

$$V_{t+1}^i = w \times V_t^i + c1 \times rand() \times (P_t^i - X_t^i) + c2 \times rand() \times (P_t^g - X_t^i) \quad (5)$$

$$X_{t+1}^i = X_t^i + V_{t+1,}^i \forall i = 1, 2 \ldots\ldots N \quad (6)$$

where

N	Number of particles in the swarm;
w	Inertia weight;
$c1, c2$	Acceleration constants;
rand ()	Uniform random value between 0 to 1;
P_t^g	Global best at generation t;
P_t^i	Best position that particle i could find so far.

IV. NATURAL EXPONENT INERTIA WEIGHT PSO

PSO is modified in different ways for better performance and efficiency. One of which is modification in the parameters of PSO like acceleration and Inertia weight. Inertia weight in PSO algorithm plays a key role in convergence and exploration process as it determines particles previous velocity to the current velocity. In standard version of PSO inertia weight taken is of constant value but better results can be obtained by varying its value so various strategies has been adopted to vary inertia weight. In this paper natural exponent inertia weight strategy [22] with its two versions e_1-PSO & e_2-PSO is adopted to improve PSO performance. In the algorithm w various with each iteration t given in equation (7) and (8) where ω_{max} is taken 0. 9 and ω_{min} is 0. 4.

$$w(t) = w_{min} + (w_{max} - w_{min}) \cdot e^{\frac{iter}{\left(iter_{max}/_{10}\right)}} \quad (7)$$

$$w(t) = w_{min} + (w_{max} - w_{min}) \cdot e^{-\left[\frac{iter}{\left(iter_{max}/_{4}\right)}\right]^2} \quad (8)$$

V. CASE STUDY

Six bus test system [21] has been considered for implementation of proposed technique. Six bus systems consist of three generators and eleven transmission lines. Line connected between bus 1 and 5 is congested as it is operating beyond the rated limits of MVA flow. Generating unit characteristics is given in table 1, Line congestion is given in table 3 as it is operating at 42. 5 MVA whereas its MVA rating is 40 MMVA. All generators are considered to take part in managing congestion due to close values of their sensitivities. Generator sensitivities (GS) are given in table 2, GS signifies that loading of a transmission line is how much related to the change in output power of each generator connected in the system. In this way we can determine and select the generators of higher sensitivities. Generators having their positive maximum value are considered as most sensitive to the flow of congested line. In large system all generators need not to participate in congestion management so generator which is having positive maximum value is treated as most sensitive generator and with negative Maximum value is least sensitive one.

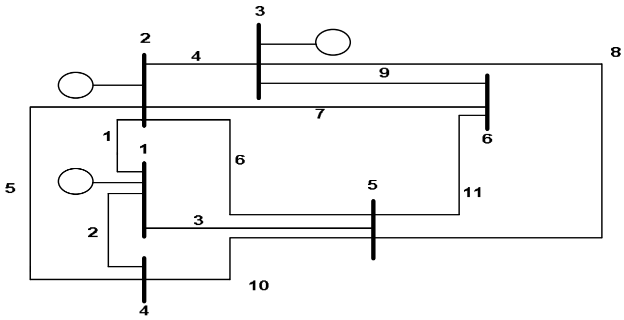

Fig. 1 Six Bus System

Table 1 Generator Data

Unit	Cost Coefficients			Generator Limits	
	Ai ($/MW2h)	Bi ($/MWh)	Ci ($/h)	P_{gmin} (MW)	P_{gmax} (MW)
1	0. 00533	11. 66	213. 1	50. 0	200
2	0. 00889	10. 333	200	37. 5	150
3	0. 00741	10. 833	240	45. 0	180

Table 2 Generator sensitivities

Unit	1	2	3
GS	0. 2396	0. 2396	-0. 1778

Table 3 Line Data

Congested Line	Rated MVA	MVA flow
1-5	40	42. 5

VI. RESULT AND DISCUSSIONS

Congestion management problem is solved by optimal rescheduling of active power of generators by standard PSO and natural exponent inertia weight strategy e1-PSO and e2-PSO. The intention of using PSO is to get minimum rescheduling cost of participating generators in congestion management due to its better convergence property. PSO technique have been already applied to several optimization problem. The program for PSO and it's variants to solve CM problem is developed in MATLAB 7. 10 on 2. 2 GHz dual core processor with 3 GB RAM.

PSO parameters taken for the study are c1&c2 =2, w=0. 5 for standard PSO whereas in other versions its value updates with every iteration. Population size is taken 70 for every trial as it is sufficient for desired results.

The test is performed on 6 bus system with congested line 1-5. The data of generating units, generator sensitivities, and MVA flows for congested line are shown in table 1, table 2 and table3. The results obtained from PSO, e1-PSO & e2-PSO are given in table 3. After rescheduling of generators MVA flow of congested line 1-5 come back from 42. 5 MVA to 40 MVA so congestion is relieved. The convergence characteristic of standard PSO is given in figure 2, e1-PSO in figure 2 and e2-PSo in figure 3. Convergence time for all the techniques is given in table 4.

Unit Output Power	PSO	e_1-PSO	e2-PSO
ΔP_{g1}(MW)	0. 8375	0. 1387	0. 0097
ΔP_{g2}(MW)	3. 4359	2. 6164	0. 0183
ΔP_{g3}(MW)	4. 2871	0. 2044	1. 4698
Total Power Output (MW)	8. 5605	2. 9595	1. 4978
Rescheduling Cost ($/h)	92. 2078	30. 9905	16. 256
Convergence Time in seconds	1. 218874	1. 328586	1. 356724

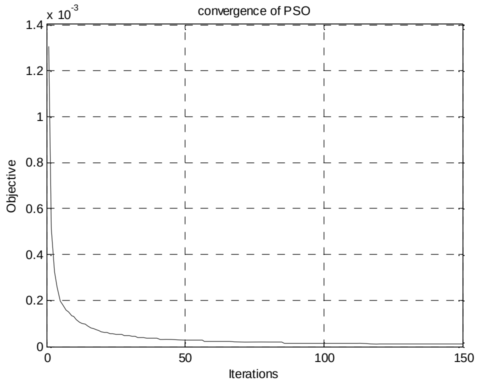

Fig. 1 Convergence of standard PSO

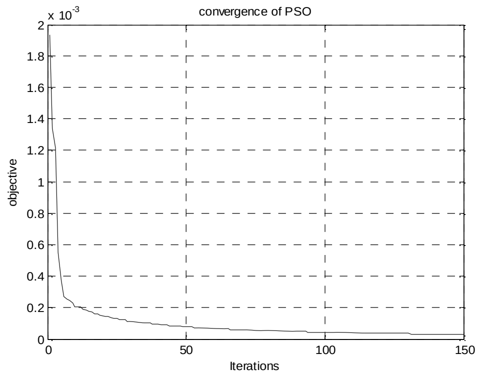

Fig. 2 Convergence of e1-PSO

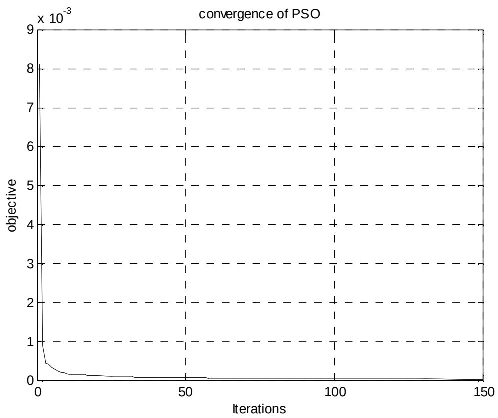

Fig. 3 Convergence of e2-PSO

V. CONLUSION

In this paper problem of transmission line congestion is solved by optimal rescheduling of generators using PSO, e1-PSO and e2-PSO. First problem formulation has been done for optimal rescheduling of generators. Problem formulation includes objective function and constraints. Rescheduling cost is taken as objective function. Generating unit limits and MVA limits are treated as constraints. MATLAB program has been developed for all the three variants of PSO for a six bus test system. Best results obtained among thirty trials are compared for better efficiency of work. Results of thirty trials shows cost of rescheduling of generators is minimum in case of e-2 PSO. Further efficiency proposed technique can be improved by hybridization of algorithm like Fuzzy PSO and Genetic Algorithm (GA) PSO.

REFERENCES

[1] J. Kennedy and R. Eberhart, "Particle swarm optimization, " in Proc. IEEE Intl. Conf. on Neural Networks, Perth, Australia, 1995, pp. 1942– 1948.

[2] Jagbondhu Hazra, Avinash K. Sinha, "Congestion management using multi-objective particle swarm optimization, " IEEE Trans. Power Syst., vol. 22, no. 4, pp. 1726-1734, Nov. 2007.

[3] S. Charles Raja, P. Venkatesh, B. V. Manikandan, "Transmission congestion management in restructured power systems", Proceedings of ICETECT, 2011.

[4] Sujatha Balaraman, N. kamaraj, "Application of differential evolution for congestion management in power system", Modern Applied Science, Vol. 4, No. 8; August 2010.

[5] T. Meena, K. Selvi, "Cluster based congestion management in deregulated electricity market using PSO", IEEE Indicon 2005 Conference, Chennai, India, 11 - 1 3 Dec. 2005, pp 627-630.

[6] E. Muneender, Member, D. M. Vinod Kumar, "Optimal rescheduling of real and reactive powers of generators for zonal congestion management based on FDR PSO", IEEE T&D Asia 2009.

[7] Ashwani Kumar, S. C. Srivastava, Senior Member, S. N. Singh, Senior Member, "A zonal congestion management approach using real and reactive power rescheduling", IEEE Trans. on Power Syst., vol. 19, no. 1, Feb. 2004.

[8] Manoj Kumar Maharana, K. Shanti Swarup, "A corrective strategy to alleviate overloading in transmission lines based on particle swarm optimization method", The Journal of Engineering Research Vol. 7, No. 1, (2010) 31-41.

[9] J Vijaya Kumar, Shaik Jameer pasha, D. M. Vinod Kumar, " Congestion influence on optimal bidding in competitive electricity market", 16th National Power Syst. Conf., 15th-17th Dec, 2010.

[10] Sawan Sen, Sandip Chanda, S. Sengupta, A. Chakrabarti, "Differential evolution based multi objective optimization of a deregulated power network under contingent state", International Journal on Electrical Engineering and Informatics, Vol. 3, No. 1, 2011.

[11] J. Hazra, Deva P. Seetharam, "A network congestion management approach considering the risk of cascading failures, " PEDES and Power India 2010.

[12] Somayeh Hajforoosh, Seyed M. H Nabavi, Mohammad A. S. Masoum, “Optimal particle swarm based placement and sizing of static synchronous series compensator to maximize social welfare”, Journal of Electrical Engineering & Technology Vol. 7, No. 4, pp. 501~512, 2012.

[13] Siti Amely Jumaat, Ismail Musirin, Muhammad Murtadha Othman, “Transmission loss minimization using SVC based on particle swarm optimization”, IEEE symposium on industrial electronics and applications, sept. 25-28, 2011 Langkawi, Malasiya.

[14] Masoud Mohammad, Rahimi Fard, Aref Jalili Irani, “Location of IPFC for congestion management lines in electricity market restructured using PSO algorithm”, Australian Journal of Basic and Applied Sciences, 5(12): 3188-3196, 2011 ISSN 1991-8178.

[15] O. Abedinia, N. Amjady, H. A. Shayanfar, A. Ghasemi, “Optimal congest management based VEPSO on electricity market”, International Journal on “Technical and Physical Problems of Engineering” June 2012 Issue 11 Vol. 4, No. 2, pp 56-62.

[16] Sina Hashemi, Saadat Hashemi, M. T. Ameli, “Optimal location of phase shifting transformer for improving power transfer limit using PSO algorithm”, International Power syst. Conf., 31 Oct. to 02 Nov. 2011 Tehran, Iran.

[17] M. R. AlRashidi, M. E. El-Hawary, “A Survey of Particle Swarm Optimization Applications in Electric Power Systems” IEEE Transactions on Evolutionary Computation, VOL. 13, NO. 4, AUGUST 2009.

[18] Rony Seto Wibowo, Naoto Yorino, Mehdi Eghbal, Yoshifumi Zoka, Yutaka Sasaki, “FACTS Devices Allocation With Control Coordination Considering Congestion Relief and Voltage Stability”, IEEE Transactions on Power System.

[19] S. K. Joshi, K. S. Pandya, “Influence of TCSC on social welfare and spot price - A comparative study of PSO with classical method” International Josurnal of Engineering, Science and Technology Vol. 2, No. 3, 2010, pp. 69-81.

[20] B. V. Manikandan, S. Charles Raja, P. Venkatesh, Manasarani Mandala, “Comparative study of two congestion management methods for the restructured power systems”, Journal of Electrical Engineering & Technology Vol. 6, No. 3, pp. 302~310, 2011.

[21] A. J. Wood and B. F. Wollenberg, “Power Generation Operation and Control”, John Wiley publishers, New York, 1996.

[22] 1J. C. Bansal, 2P. K. Singh 3Mukesh Saraswat, 4Abhishek Verma, 5Shimpi Singh Jadon, 6, 7Ajith Abraham, “Inertia Weight Strategies in Particle Swarm Optimization”, Third World Congress on Nature and Biologically Inspired Computing, 2011.