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OPTIMAL CONGESTION MANAGEMENT USING VARYING INERTIA WEIGHT PSO

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Abstract: To propose a technique for reducing the number of participating generators and optimum rescheduling of their outputs while managing congestion in a system at minimum rescheduling cost with the consideration that, there is no need to reschedule the outputs of generators whose generations are less critical to the congested line flow. The main aim of this work is to overcome the transmission overloading at the same time ensuring the economy of the system. This work proposed an evolutionary technique PSO with varying inertia weight for implemented to solve the congestion management problem.

Key words: congestion management, Economic system operation, PSO (particle swarm optimization), VIWPSO (varying inertia weight particle swarm optimization).

1. Introduction

With electricity market, power system infrastructure has subjected to huge change in the planning, operations and management. With the introduction of electricity market in power sector brings competition with benefits, but on the other hand made the power sector face unprecedented problems. The electricity market has salient characteristics, which make the operation of competitive markets a major challenge. Some of the limitations in electricity are lack of major storage capability, instant manufacturing nature of electricity, and central role played by transmission and distribution networks. With rapid growth of electricity market trades and the availability of insufficient transmission resources leads to network congestion. Real-time transmission congestion is defined as the operating condition in which there is not enough transmission capability to implement all the traded transactions simultaneously due to some unexpected contingencies. It may be alleviated by the following processes:

A. Rescheduling of active power of generators.

B. Load shedding.

Various advance optimization techniques have been derived from optimization behavior of natural things and can be applied in solving the complex problems like power considering the single objective function including genetic algorithm (GA), Simulated Annealing (SA), Tabu Search (TS) and PSO Algorithm. These are Evolutionary programming algorithms (EP) which use mechanics of evolutions to produce optimal solutions to a given problem. It works by evolving population of candidate solutions towards the global optimum solution. Some of the literature is discussed below:

Ch. Naga Raja Kumari , M. Anitha [11] discusses a solution for congestion relief. This paper has been explored the Day-Ahead market scheduling under normal as well as congestion states. The re-schedule and load curtailment approaches have been applied to the congestion relief.

B. V. Manikandan, S. Charles Raja, P. Venkatesh and Manasarani design [8] mentioned cluster/zone technique and relative electrical distance (RED) technique for congestion management and area unit compared supported the thought of parameters. C. M. Wankhade, A. P. Vaidya [9] have discussed congestion management with the application of Optimal Power Flow solution by using Lagrange's Multiplier Method (LMMS) and Conventional algorithm (NBOPF) and compared them. Guguloth Ramesh, T. K. Sunil Kumar [14] have proposed an approach to alleviate Congestion in the transmission lines by connecting Distributed Generation (DG) of micro grid at load bus and a method to determine the optimal location of DG unit based on transmission line relief sensitivity based approach. K. Vijay kumar [18] has mentioned best location of FACTS devices i.e. TCSC and UPFC to alleviate congestion within the network by mistreatment genetic algorithmic rule (GA) technique.

2. Deregulation and Privatization of PS

The performance of a market is measured by its financial aid. Financial aid could be a combination of the price of the energy and also the advantage of the energy to society as measured by society's disposition to acquire it. If the demand for energy is assumed to be freelance of value, that is, if demand has zero value physical property, then the financial aid is just the negative of the entire quantity of cash got energy. Real markets continuously operate at lower levels of financial aid.

A. Vertically Integrated Operation:- Vertically Integrated model implies gap to competition those tasks that are in an exceedingly vertically integrated structure, coordinated collectively with the target of minimizing the entire prices of operational the utility. In such a conventional structure, all the management functions, like automatic generation management (AGC), state estimation, generation dispatch, unit commitment, etc., are administrated by associate degree energy management system.

B. Unbundled Operation:- In a competitive power market situation, besides generation, loads, and line flows, contracts between commerce entities additionally comprise the system call variables. The subsequent pool and bilateral competitive structures for the electricity market have evolved/are evolving:

I. Single auction power pools, wherever wholesale sellers (competitive generators) bid to provide power in to one pool. Load serving entities (LSEs or obtainers) then buy wholesale power from that pool at a regulated value and sell it to the retail masses.

II. Double auction power pools, wherever the sellers place in their bids in an exceedingly single pool and also the consumers then vie with their offers to shop for wholesale power from the pool and so sell it to the retail masses.

Transmission congestion is additionally outlined as overloading in transmission lines which can occur due varied surprising contingencies like massive load variations, outburst of load demand, outage of transmission lines, transformers, generators, etc. Any of those, might cause system parameters to exceed the boundaries that results in associate degree insecure system. This necessitates the facility system operator to be attentive to keep the system performance within the traditional condition. The assuaging overload cable within the emergency condition could be a vital drawback in power grid operation.

3. Problem Formulation

Objective function satisfies the desired task to be done. PSO algorithm minimizes objective function in each iteration while maintaining the constraints within the bounds. Generator Sensitivities (GS) are included in the objective formulation. Is shows the change in the power flow of a line between two buses due to change in the output of generator g. The objective function is minimization of rescheduling cost of generators for managing congestion.

3.1. Constraints

To ensure the operation of system within operating range with feasible solutions inequality and equality constraints are incorporated.

$$\text{Minimize} \quad \sum_{g}^{Ng} C_{P_g}(\Delta P_g)\Delta P_g \qquad (1)$$

In the present work constraints are power flow constraint (2), operating limit constraints (3) (4)

Subject to $$\sum_{g}^{Ng}\left((GS_g)\Delta P_g\right) + F_k^o \le F_k^{max} \quad (2)$$

$$P_g^{min} \le P_g \le P_g^{max} \quad (3)$$

$$P_g - P_g^{min} = \Delta P_g^{min} \le \Delta P_g \le \Delta P_g^{max} = P_g^{max} - P_g \quad (4)$$

Where:

GS_g	:	Generator sensitivity
F_k^o	:	MVA flow
F_k^{max}	:	MVA flow limit
ΔPg	:	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 output

4. Particle Swarm Optimization

Optimization could be a procedure of finding and scrutiny possible answers unless best solution has been found. Amongst all biological process techniques PSO could be a relatively new computation technique that is galvanized by natural aspects like fish schooling, bird flocking and human relation. It explores world best answer through exploiting the particle's memory and swarm memory. PSO has gained unbelievable recognizition throughout last decade thanks to convenience of realization, quick convergence and promising improvement ability in numerous issues. This improvement formula was instructed by Kennedy & Eberhart in 1995 that was additional changed by heap of researchers to boost the performance of it. Therefore heap of variants of PSO is currently offered in literature, that shown superior results over basic PSO in terms of answer accuracy and speed of convergence. PSO is initialized with a population of random solutions. Every potential answer is additionally allotted an irregular speed, and also the potential solutions, known as particles, square measure then "flown" through the matter area. Every particle keeps track of its coordinates within the drawback area that square measure related to the simplest answer (fitness) it's achieved thus far. This worth is termed pbest. Another "best" worth that's half-tracked by the worldwide version of the particle swarm optimizer is that the overall best worth, and its location, obtained thus far by any particle within the population. This location is termed gbest. The careful implementation steps of PSO square measure as follows:

Step1: **Initialize swarm size**

Initialize a population of particles with random positions and velocities on d dimensions within the drawback area.

Step2: Judge fitness performs for each particle, judge the required improvement fitness perform in d variables.

Step3: Compare particle's fitness analysis with particle's pbest If current worth is best than pbest, then set pbest worth up to the present worth, and also the pbest location up to the present location in d-dimensional area.

Step4: Compare fitness analysis with the population's overall previous best if current worth is best than gbest, than reset gbest to the present particles array index and worth.

Step5: modification the rate of the particle consistent with equation (5)

$$v_i^{k+1} = v_i^k + c_1 r_1\left(x_{pbest} - x_i^k\right) + c_2 r_2\left(x_{gbest} - x_i^k\right) \quad (5)$$

Where

v_i^{k+1}:	**Particle velocity at current iteration (k+1)**

v_i^k :	Particle velocity at iteration k
r_1, r_2:	Random number between [0, 1]
c_1, c_2:	Acceleration constant

The acceleration constants c1 and c2 in equation (5.1) represent the coefficient of the random acceleration terms that pull every particle toward pbest and gbest positions. c1 and c2 every capable two for pretty much all applications C Rate Vmax was therefore the sole parameter we regularly set it at regarding 10-20% of the dynamic vary of the variable on every dimension.

Step6: Change the position of the particle according to equation (6)

$$x_i^{k+1} = x_i^k + v_i^{k+1} \quad (6)$$

x_i^{k+1} : Current particle position at iteration k+1
x_i^k : Current particle position at iteration k

Step7: Loop to step 2 until a criterion is met, usually a sufficient good fitness or a maximum number of iterations (generations).

4.1.Varying Inertia Weight PSO

The use of inertia weight w has provided improved performance in a very variety of applications. As originally developed, w usually is shriveled linearly from regarding zero.9 to 0.4 throughout a run. Appropriate choice of Associate in inertia weight provides a balance between world and native exploration, and leads to fever iterations on the average to seek out a sufficiently best resolution. Change the velocity particle and position particle according to equations.

$$v_i^{k+1} = \omega v_i^k + c_1 r_1 (x_{pbest} - x_i^k) + c_2 r_2 (x_{gbest} - x_i^k) \quad (7)$$

$$\omega = (\omega_{max} - \omega_{min}) \times \frac{(iter_{max} - iter)}{iter_{max}} + \omega_{min} \quad (8)$$

Where, ω: Inertia weight, ω_{max}: Maximum value of weighting factor, ω_{min} : Minimum value of weighting factor , $iter_{max}$: Maximum number of iteration, Iter : Current number of iteration.

5. Test System

The IEEE thirty bus system is employed during this work to check the planned algorithmic rule PSO. This technique is employed as a typical check system to review completely different power issues and judge programs to investigate such issues. This technique consists of vi generation units and forty one transmission lines

Table1: Line overload in IEEE 30 bus system

Line overloaded	MVA limit	MVA flow
2-1	170	130
9-2	66	65

Congestion is especially overloading in line that should be should be solved by the strategy varied inertia Weight particle swam improvement (VIW-PSO) overloading alleviation is completed in line as given table 1 Alleviation of line overloading is completed by distributing the load of over laden line then step-down of generation price is completed. Optimal results obtained at different population sizes by LDIW PSO are given in the table 3. Figure 2 to 4 shows the convergence characteristic of optimal cost v/s generations or iterations at different population sizes. The generator cost coefficients is mentioned in appendix A.2. Table 3 shows the result that is simulated for IEEE 30 bus system for 30 trials. From the table3 given below it has been clearly observed that population size= 10 with iteration (Itermax = 800) is giving minimum value i.e. 803.364 $/h with the generation schedule Pg1 = 138.619 MW, Pg2 = 69.681 MW, Pg3 = 24.953 MW, Pg4 = 19.784 MW, Pg5 = 20.621 MW, Pg6 = 13.003 MW.

Table 2: Parameters of LDIW-PSO

Maximum Iteration	100	300	500	800
Population size	5, 10, 20	5, 10, 20	5, 10, 20	5, 10, 20
$C_1=C_2=$	0.01	0.01	0.01	0.01
W_{max}	0.9	0.9	0.9	0.9
W_{min}	0.4	0.4	0.4	0.4

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Table 3: Optimal Cost of IEEE 30 bus system by LDIW PSO at different population sizes

S.NO	Population	Iterations			
		100	300	500	800
1	5	810.704	811.564	858.78	830.810
2	10	856.139	886.679	896.139	803.364
3	20	934.811	987.162	1006.442	938.897

Table 4: Result of LDIW-PSO

GENERATOR	MW
1	138.619
2	69.681
3	24.953
4	19.784
5	20.621
6	13.003
Total Generation(MW)	286.661MW
Generation Cost($/Hr)	803.364 $/hr

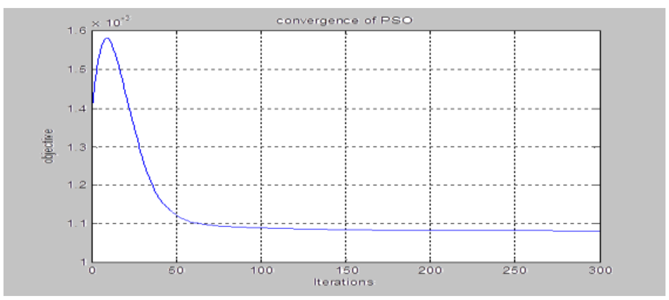

Figure 6.2 (a) Convergence Characteristic for Iteration 100

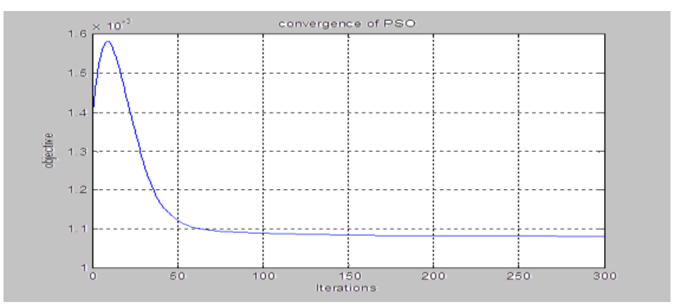

Figure 6.2(b) Convergence Characteristic at Iteration 300

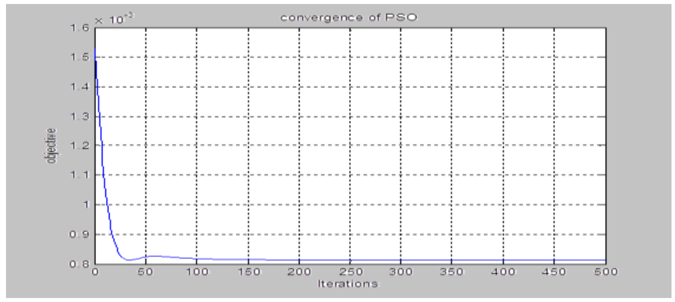

Figure 6.2(c) Convergence Characteristics at Iteration 500

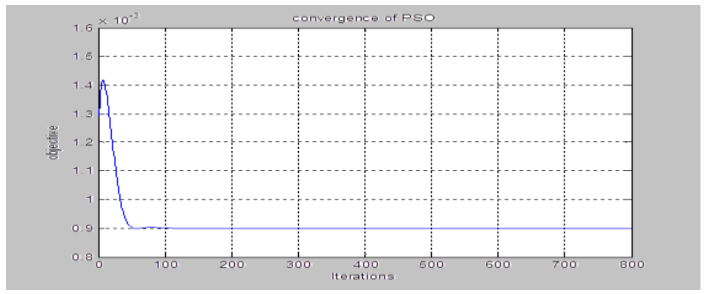

Figure 6.2 (d) Convergence Characteristic at Iteration 800

Convergence Characteristics at Population 10

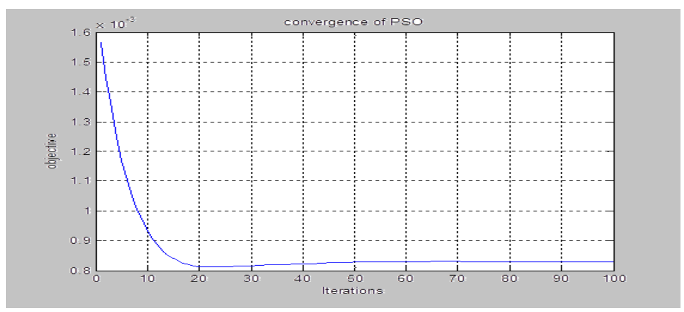

Figure 6.3(a) Convergence Characteristic for Iteration=100

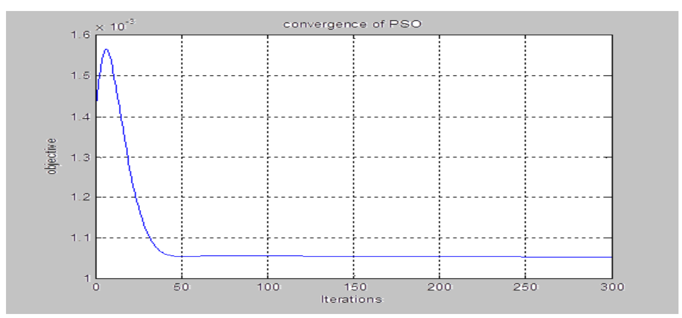

Figure 6.3(b) Convergence Characteristic for Iteration=300

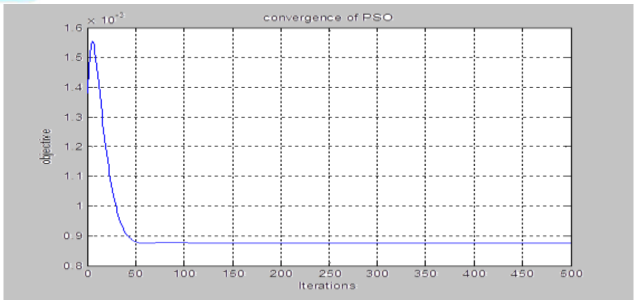

Figure 6.3(c) Convergence Characteristic for Iteration=500

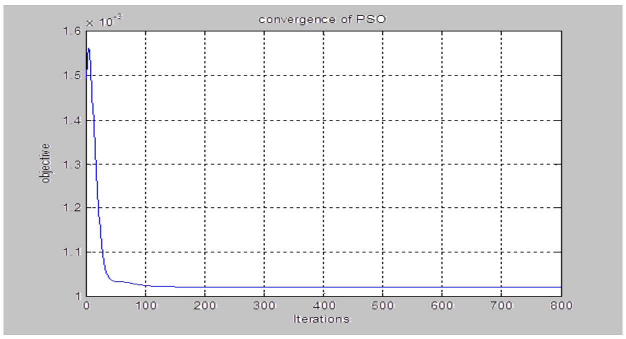

Figure 6.3(d) Convergence Characteristic for Iteration=800

Table 5 Results of LDIW-PSO compared with NR and QN-OPF methods

OPTIMAL SOLUTION(MW)	N-R(MW)	Q-N(MW)	LDIW-PSO (MW)
P_{G1}[MW]	99.211	170.237	138.619
P_{G2}[MW]	80.00	44.297	69.681
P_{G3}[MW]	50.00	28.903	24.953
P_{G4}[MW]	20.00	17.474	19.784
P_{G5}[MW]	20.00	12.174	20.621
P_{G6}[MW]	20.00	18.468	13.003
Total Generation[MW]	289.211MW	291.553MW	286.661MW
Generation Cost($/hr)	901.918 $/hr	807.782 $/hr	803.364 $/hr

In Table 6, the total generator fuel cost obtained from the proposed method is lower than genetic algorithm(GA), classical economic dispatch and standard load flow(EDLF), Dommel Tinney (DT), improved particle swarm optimization(IPSO). It renders better solutions and converges to a better solution in a faster manner.

Table 6 Comparing optimal cost of generation with evolutionary methods

Optimal Solution	GA (MW)	EDLF (MW)	DT (MW)	IPSO (MW)	LDIW-PSO (MW)
P_{G1}[MW]	179.39	192.65	138.56	198.69	138.619
P_{G2}[MW]	48.83	48.92	57.56	36.16	69.681
P_{G3}[MW]	21.84	19.26	24.56	17.64	24.953
P_{G4}[MW]	21.75	10.58	35.00	11.45	19.784
P_{G5}[MW]	12.05	10.79	17.93	12.15	20.621
P_{G6}[MW]	12.36	12.24	16.91	11.87	13.003
Total Generation[MW]	296.22 MW	294.44 MW	290.52 MW	287.96 MW	286.661 MW
Generation Cost($/hr)	803.5 $/hr	805.45 $/hr	813.74 $/hr	827.13 $/hr	803.364 $/hr

6. Conclusion

In this thesis work, the optimal congestion management approach based on linearly decreasing inertia weight particle swarm optimization (LDIW-PSO) is used which efficiently minimize rescheduled generation cost. The problem of congestion is modeled as an optimization problem and solved by particle swarm optimization technique. Redispatched generators are selected based on the outage of line. Line outage due to unexpected line outage & sudden load variation is considered in this work. The method has been tested on modified IEEE 30-bus and successfully implemented. The proposed method is compared with classical method and also with evolutionary method. The proposed approach gives better result and also converges to an optimal solution in a faster manner. The proposed approach is useful for ISOs in managing the transmission congestion in a deregulated electricity environment.

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