PSO based simulation of Economic Load Dispatch of Transmission Power

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Abstract - Economic Load Dispatch (ELD) is an important criterion of a power system control and operation due to high power generation cost, increasing demand of electric energy and improper availability of energy resources. With the fast developing industrial era and other power requiring infrastructure, the varying load demand requires the balanced sharing of demand-power and the losses among themselves. The sharing should be based on the optimized generation cost, power loss minimization and other constraints. Conventional optimization methods are, in general, not able to locate the global optimization. This paper presents a Particle Swam Optimization (PSO) based approach to the optimized solution of power flow problem. Particle Swam Optimization has many interesting and Successful applications in a variety of complex problems. The well-known IEEE 14-bus is implemented here to present the results of this investigation work.

Keywords: Congestion Loss, Economic Load Dispatch (ELD), IEEE 14-Bus System, MATLAB, Particle Swarm Optimization, Power Distribution Cost.

I. INTRODUCTION

The purpose of a power distribution system is to supply sustained and cost efficient power to the consumers. Each element of the system contains high end technology based system components like Generators, transformers, power electronic devices, Supervisory Control And Data Acquisition (SCADA), Power Lines, etc. Because of presence of a number of control elements the system operation, stability, control, optimization, balance, settling becomes a complex and distributed task. The problem of ELD is to minimize the total cost of power generation at various generators, minimization of Line loss and other distribution loss and to satisfy the loads. In the recent approaches to the global optimized solution of a multi-dimensional problem the most potential approach is by using swarm intelligence and evolutionary computation. Particle swarm optimization (PSO) is a population-based algorithm that gives one of the best solutions for ELD problem.

The approaches that can be implemented to find a solution, with the most possible optimization in power distribution cost, can be broadly classified into Heuristic approach and Meta-Heuristic approach. Heuristic approaches are easy to implement as compared to Meta-Heuristic approaches. But, the Heuristic approach does not always promise the best solution because of its non-iterative implementation behaviour.

In literature, there are many methods proposed for distribution system planning. A list of the conventional and advanced methods is given as follows:

A. Traditional Techniques

- Newton Raphson
- Fast Decoupled
- Gauss Seidal
- Branch Bound
- Dynamic Programming
- Lagrange Algorithm

B. Advanced Techniques

- Branch Exchange
- Neural Network
- Honey Bee Optimization
- Dijkstra Algorithm
- Harmony Search
- Greedy Snake
- Tabu Search
- Pattern Search
- Meta Heuristic
- Ant Colony Optimization
- Differential Evolution
- Biogeography Based Optimization
- Ladder Method
- Bee Hive
- Fuzzy Logic
- Genetic Algorithm
- Particle Swarm Optimization

An overview of the common methods is given as below:

A. Ant Colony Optimization Algorithm:

This method has an exceptional feature to find the shortest path. It is mainly used as a model to determine optimal location and size of Distributed Generator in a power distribution system.

B. Genetic Algorithm (GA):

It is based on natural evolution stimulated technique like recombination, mutation, crossover, reproduction, selection etc. To diminish power loss on a system GA is one of the artificial intelligent-search based methods for sizing and placement of distributed generation.

C. Tabu Search (TS):

Tabu Search is a Meta-Heuristic approach to track local shortest path from a memory list called Tabu-List that contain the latest search history.

D. Simulated Annealing (SA):

This is a meta-heuristic method for the optimization of a given function in a large search space. This method examines a function for new solutions to optimally locate DG. This method can also be used to determine the size of DG to reduce the losses, emission and survive in uncertainties.

E. Particle Swarm Optimization (PSO):

Particle Swarm Optimization is simple algorithm. It iteratively solves a function where a group of variables have their values adjusted closer to the member whose value is closest to the objective at any given set of parameters.

II. LITERATURE REVIEW

A number of optimization techniques are proposed by many researchers and scholars in their work. A review of the various power distribution optimization techniques and a comparative analysis of the various techniques is presented in reference [1-5]. These works present the soft computing approaches in solving ELD problem by considering reliability of the system and uncertainty in the power requirement by the market. The power loss reduction of a distribution system can be achieved by focussing on any of the parameter that directly or indirectly caused power loss.

A DG Unit position based power reduction method is presented in [6]. A solar Photo Voltaic (SPV) energy utilization based optimized approach is presented in [7, 8, 9 and 10]. Reference [11-14] presents PSO based Optimal Power Flow (OPF) system operational approach by reducing the power loss for the test system by reducing the real and reactive power loss. An optimal capacitor placement and sizing (OCPS) problem minimization approach is performed using PSO in [15] to test a power system performance. This work shows an improvement in results as compared to its referenced work.

Reference paper [16] presents a PSO based algorithm to minimize the system operating cost by using a new approach for load ability enhancement in power system with wind energy sources, without violating the system constraints. An optimal location and sizing of Static Var Compensator (SVS) based approach using PSO is implemented in [17] to minimize load voltage magnitude deviations and network losses on an IEEE 14-Bus system. In [18] a PSO based optimization is tested to maximize the load ability of the power system with load generation balance as equality constraint. Results from this approach shows that the implementation of PSO has enhanced the transmission system load-ability with increased voltage profile.

An optimal placement of STATCOM device for voltage profile improvement, loss reduction, and THD (Total Harmonic Distortion) reduction in distribution & transmission networks is presented in [19] to give the superlative solution with statistical significance and a great degree of convergence. Reference [20] presents a Global Neighborhood Algorithm (GNA) based approach on the combinatorial optimization problems which has a finite set of possible solutions for performing the iterations to optimize the system performance based on a fixed number of optimization parameters.

III. MODELLING AND IMPLEMENTATION OF PSO

Swarm Optimization is a population-based stochastic optimization technique that is inspired by the social behaviour of the flocking of bird or the schooling of fish. In PSO, the best solution to any problem is searched by following a sequence of better solution. If it is compared to the flocking of bird then each single solution is a bird or particle in search of the space of food (best solution). All particles have fitness values evaluated by their “fitness function” and have “velocities” that direct the flying of the particles. Initialized with a set of random solutions, PSO searches for the optimal solution by updating the best evaluated solution after successive iteration. All particles are updated by two ‘best’ values. One is called the ‘pbest’ or ‘personal-best’ implying the best solution or fitness achieved so far. The other one is the ‘gbest’ or ‘global-best’ implying the best solution obtained by any particle. The velocity and the position of the individual particle in the search space is calculated as,

$$V = w*V' + C1*rand\,(Pbest - X') + C2*rand(Gbest - X')$$

$$X = X' + V$$

Where,

V = velocity of particle

X = position of particle

a) Pseudo code of PSO

1. The operation has to be performing by preparing electric data network.
2. Set of attributes of PSO conferring different PSO variation (i.e. swam size, maximum Number of Iteration, number of neighbours, initial iteration, etc.).
3. Randomly selecting particles positions and velocities for operations.
4. Evaluate the objective function by means of the optimal DC power flow.
5. Upgrade the best overall, individual and local element positions.
6. Number of iterative depends on the best achieved value, stopping criterion will have to-
   i. Increase iterations counter for operation.
   ii. For each element update positions (or velocities where applicable) by using consistently equations to the different PSO variations (GPSO, LPSO or QPSO).
   iii. Check velocity limits (where applicable).
   iv. Update swarm.
   v. Check swarm limits.
   vi. Evaluate the objective function by means of the optimal DC power flow.
   vii. Update the best overall, individual, and local element positions.
7. End

b) Network Data

The data used for the TEP implementation are those wanted for the DC prototype. The dimension of the difficulty is given by the number of right of ways where it probable is to add circuits.

c) Restriction settings

Some restrictions are very important instruction to assure the convergence of PSO algorithms. The number of elements *N* is a difficulties dependent restriction, which should be chosen conferring to the dimension of the problem. There is no formal procedure to select such restriction, which is mainly explained by trial and error operations.

d) Swarm and velocities bounds

In order to limit the finding space, the minimum and maximum bounds of each element has to be defined.

e) Swarm and velocities initialization

The technique of ordinary uniform initialization is normally used in most works to prepare the initial swarm when there is no much evidence to solve the difficulties. Building preliminary solutions using this criterion will allow the optimization algorithm to recruit in regions nearer from optimal values, which can speed up the optimization operation

f) Stopping criteria

In this work, the criterion used to stop the iterative process is the maximum allowed number of iterations, which also Limits the number of function evaluations. In practice, search stagnation could also have been used as an alternative Stopping criterion. There is no formal procedure to select the maximum number of iterations; in this work, it was chosen by a trial and error process taking into account the dimension of the problem.

g) Search space

Suppose the number of candidate corridors to be *m* (which is also the dimension of the problem) and *x* max the maximum feasible number of candidate circuits in each corridor, then the search space is given by the number of possible topologies $(xmax+1)m$; evidently, feasible and unfeasible network topologies are included in this calculation.

IV. SIMULATION RESULT

This section presents the practical results associated with the simulation of PSO based implementation of standard IEEE 14-bus test system. In the IEEE 14-bus system shown in Fig. 4.1, there are 14 buses, Bus 1, 2 and 7 are generator buses; and the rest are load buses.

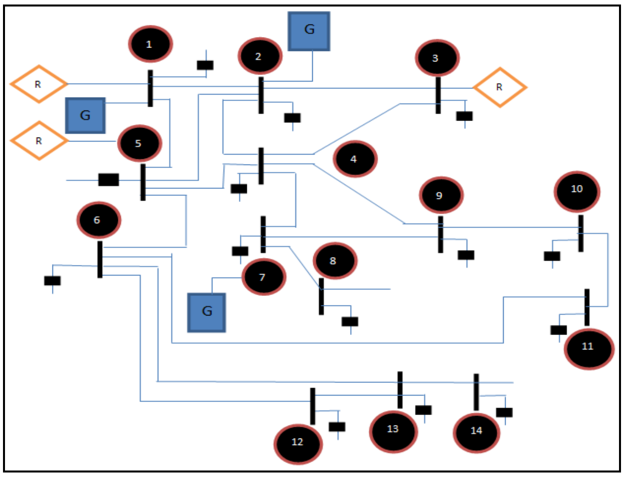

Fig. 4.1 Network diagram of IEEE 14-bus system.

The generator bus generates the power and that power is distributed in different areas by line buses. There are three reactive power / synchronous generators at bus 1, 3 and 5

The IEEE test system has been designed to incorporate all characteristics of real power Systems in a concentrated system to provide a unique system for comparisons among different strategies. The Flow chart of the algorithm implemented in this work is presented in Fig. 4.2.

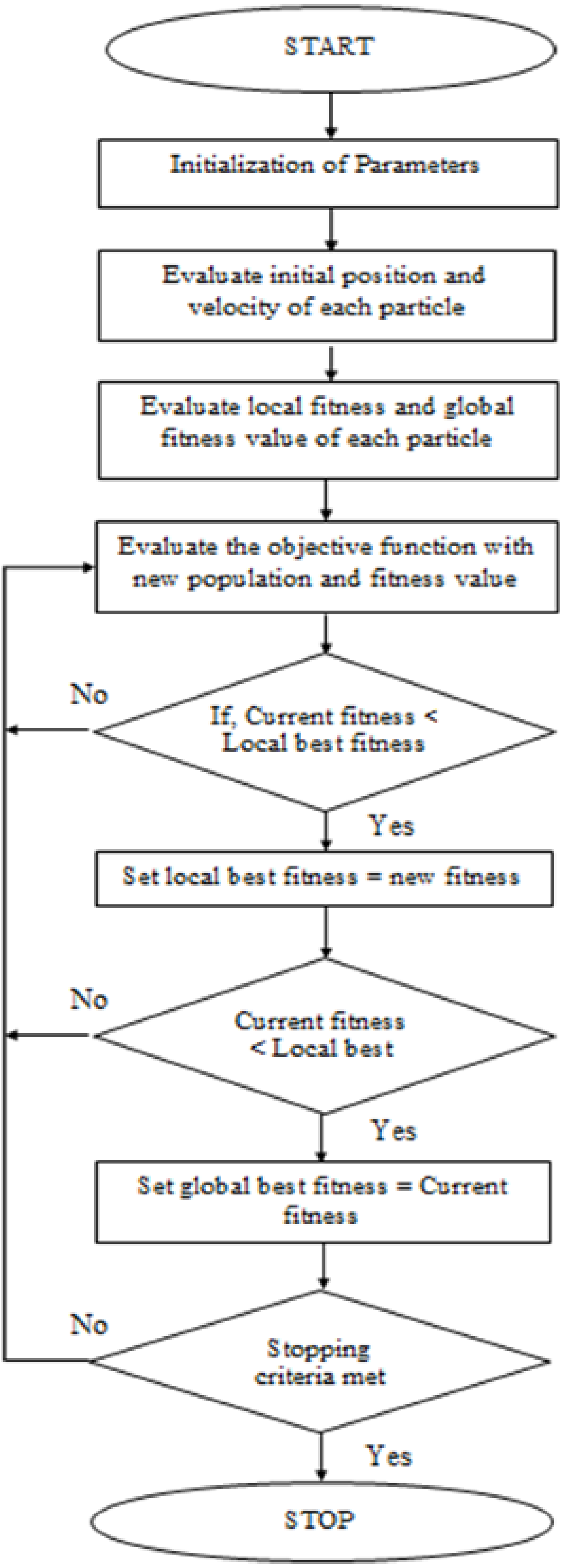

Fig. 4.2 PSO Algorithm Flow-Chart

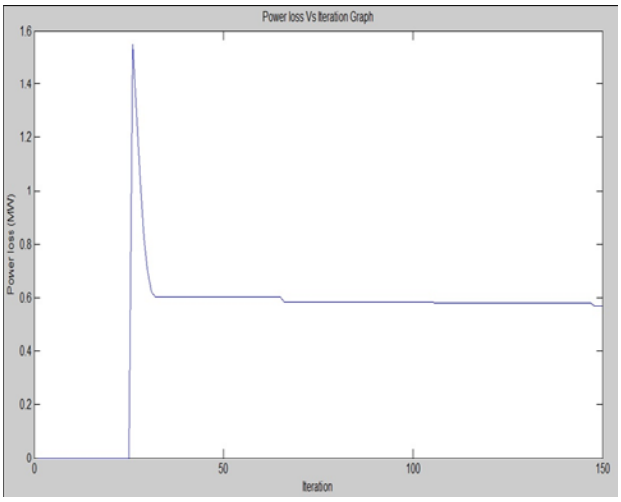

Fig. 4.3 Simulation output of PSO based minimization of Power loss in IEEE 14-Bus System in proposed work

Fig. 4.3 shows the Simulation output of PSO based minimization of Power loss in IEEE 14-Bus System in proposed work. Table 1 presents the Line Data that is used in the simulation of power loss optimization in the present work. Table 2 gives the details of the Bus-Type and Power related data of the IEEE 14-bus system. Buses are used to transfer the load to different lines data so that the power is not wasted and a Bus can transfer the power to another Bus with a load to through Bus-Line.

TABLE 1. BUS DATA OF IEEE 14-BUS SYSTEM

From Bus	**To Bus**	**R (per unit)**	**X (per unit)**	**B/2 (per unit)**
1	2	0.01938	0.05917	0.0264
1	5	0.05403	0.22304	0.0264
2	3	0.04699	0.19797	0.0219
2	4	0.05811	0.17632	0.0170
2	5	0.05695	0.17388	0.0173
3	4	0.06701	017103	0.0064
4	5	0.01335	0.04211	0.0
4	7	0.0	0.20912	0.0
4	9	0.0	0.55618	0.0
5	6	0.0	0.25202	0.0
6	11	0.09498	0.19890	0.0
6	12	0,12291	0.25581	0.0

6	13	0.06615	0.13027	0.0
7	8	0.0	0.17615	0.0
7	9	0.0	0.11001	0.0
9	10	0.03181	0.08450	0.0
9	14	0.12711	0.27038	0.0
10	11	0.08205	0.19207	0.0
12	13	0.22092	0.19988	0.0
13	14	0.17093	0.34802	0.0

TABLE 2. IEEE 14-BUS SYSTEM PARAMETERS

Bus	Type	Vsp	PGi	QGi	PLi	QLi
1	1	1.060	221.467	14.186	221.467	14.186
2	2	1.045	40	42.4	21.7	12.7
3	2	1.010	0	23.4	94.2	19.0
4	3	1.0	0	0	47.8	-3.9
5	3	1.0	0	0	7.6	1.6
6	2	1.070	0	12.2	11.2	7.5
7	3	1.0	10	0	0.0	0.0
8	2	1.090	0	17.4	0.0	0.0
9	3	1.0	0	0	29.5	16.6
10	3	1.0	0	0	9.0	5.8
11	3	1.0	0	0	3.5	1.8
12	3	1.0	0	0	6.1	1.6
13	3	1.0	0	0	13.5	5.8
14	3	1.0	0	0	14.9	5.0

V. CONCLUSION

This paper has proposed the PSO algorithm as a new evolutionary technique to optimize the power loss. The approach can be applied for a wide range of Power System optimization problems. It presents good results for the loss reduction in particular. These results were taken on number of iteration and by selecting the best value from number of iteration for optimizing the load, confirming the potential and the effectiveness of the proposed approach. These results were shown on the graph plotted above.

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