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Distributed Generation Allocation and Sizing using Various Meta Heuristic Optimization Techniques: A Review

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Abstract— Distributed generation units are small renewable sources of energy located at or near the point of use in distribution system to increase voltage stability and minimise power loss. With the worldwide growing popularity of DG it is essential to determine optimal location and size. In this paper different method for optimum allocation of DG in distribution system such as Cuckoo Search Algorithm, Firefly Algorithm, Genetic Algorithm, Harmony Search Algorithm, PSO, Artificial Bee Colony, Ant Colony Optimization etc are reviewed. These natured inspired techniques are more flexible and fast optimization methods.

Key words: Distributed Generation, Ant Colony Optimization, Artificial Bee Colony, Harmony Search Algorithm, Genetic Algorithm, Particle Swarm Optimization, Firefly Algorithm, Cuckoo Search Algorithm

I. INTRODUCTION

Increasing demand for electrical energy to remote areas raises heavy distribution losses in transmission system. DG improves voltage stability in the system and consequently minimises power losses which have increased the desirability of DGs in recent years. It is easy to find the site for installation of DG nearer to the customers which diminishes transmission and distribution costs. On the other hand, with increasing number of DGs installation cost goes up. Allocation and sizing of DGs in distribution system has became the matter of concern for researchers and a number of attempts have been made to optimize number and size of DGs. DG-unit deployments are attained via different optimization methods such as cuckoo search algorithm(CS), genetic algorithm (GA), particle swarm optimization (PSO) and many more. In this context different methods applied for DG allocation and sizing are reviewed.

II. ANT COLONY OPTIMIZATION ALGORITHM

The Ant Colony Optimization (ACO) algorithm is originally inspired by the biological behaviour of the ants and their way of communication. The ability of real ants to find the shorts paths in their movement from and to their nests in search of food leads this inspiration. Real ants do communicate with each other through pheromones. As an optimization technique, the ACO has been successfully applied to solve DG optimization problems. Kasaei [1] has used ACO for proper allocation of DGs and capacitors for IEEE 33-bus system and concluded that power loss was reduced by 76.31%. Farhat [2] has experimented on 69-bus feeder standard test system for optimal allocation and sizing of DGs by ACO. It is concluded that real power losses reduced to 14.351 Kw from 221.436 Kw by installing 3 DG units at bus no. 20, 61 and 64.

III. ARTIFICIAL BEE COLONY ALGORITHM

The Artificial Bee Colony (ABC) Algorithm works on distinguished behaviour of employed bee, onlooker bee, and scout bee in the colony. The employed bee searches food source randomly and inform onlooker bees waiting in the hive regarding the amount of food by dancing. ABC algorithm is based on behaviour and movement of these various kinds of bees and their strategy to find best nectar. Fig.1 shows the flow diagram of ABC algorithm. Selve [3] applied ABC for optimal allocation and sizing of DGs on IEEE 34 bus radial distribution system and concluded that before allocation of DG the loss was found to be 0.09770 MW and after DG penetration the loss was found to be 0.0022 MW. Kori et al. [4] have diminished power loss in distribution system by applying ABC algorithm for allocation and sizing of DG in 69-bus radial distribution feeder system.

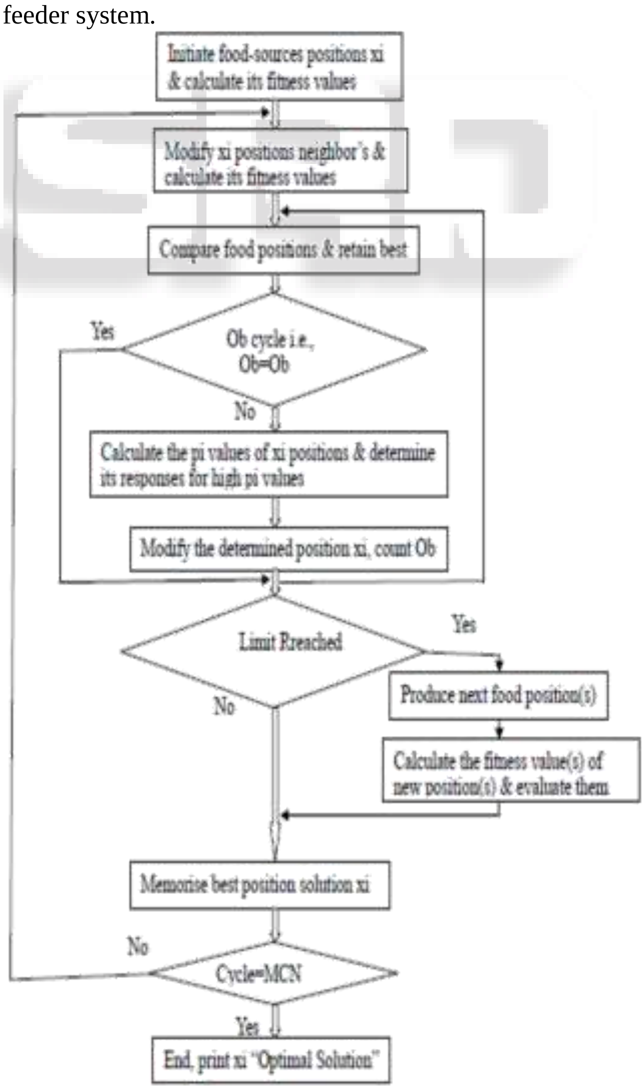

Fig. 1: Flow diagram of Artificial Bee Colony algorithm

IV. HARMONY SEARCH ALGORITHM

The Harmony Search Algorithm (HSA) is a Meta heuristic population based search algorithm derived from the natural phenomena of musicians' behaviour when they collectively play their musical instruments in search of perfect state of harmony. Steps included in HSA are parameters initialization, initializing the harmony memory (HM), and iterations of improvising a new harmony from the harmony memory and updating harmony memory. Fig.2 shows the flow diagram of HSA algorithm. Liu et al. [5] have solve the optimal allocation and sizing issue in modified IEEE 33-bus test system by multi objective harmony search technique. Sangeetha and Jalendiran [6] have applied HSA on 33-bus system and concluded that the ratio of percentage loss reduction to DG size is highest when number of DG installation locations is three.

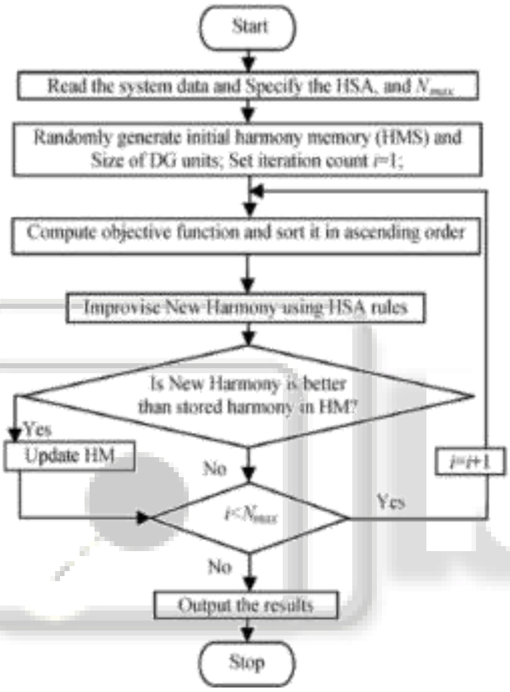

Fig.2 Flow diagram of Harmony Search Algorithm

V. GENETIC ALGORITHM

Genetic Algorithm (GA) is a technique inspired from the genetic and evolution mechanisms observed in natural systems. GA Program comprises phases of creating an initial population, evaluating a fitness function and producing a new population. The GA method starts with a randomly generated initial population. Individuals and subsequent generations are eliminated or duplicated according to their fitness values. Number of iterations should be selected to obtain the needed convergence and accuracy. Fig.3 shows the flow diagram of GA algorithm. Shereen [7] has placed two types of DGs capable of minimizing real and reactive power losses at power factor of unity and 0.8 in 33-bus test distribution system. Using DG with 0.8 power factor reduce system power loss about 70% more than DG with unity power factor. Sulaiman et al. [8] have demonstrated DG allocation on 69-bus distribution system by genetic algorithm and concluded that installation results in minimization of power losses. Singh et al. [9] have described the method of DG allocation in 16-bus and 37-bus systems by using genetic algorithm and compared impact indices for different cases. Yammani et al. [10] have tested on 37-bus and 69-bus Distribution Systems for optimal allocation of DGs by genetic algorithm and proposed that it minimizes power loss in system.

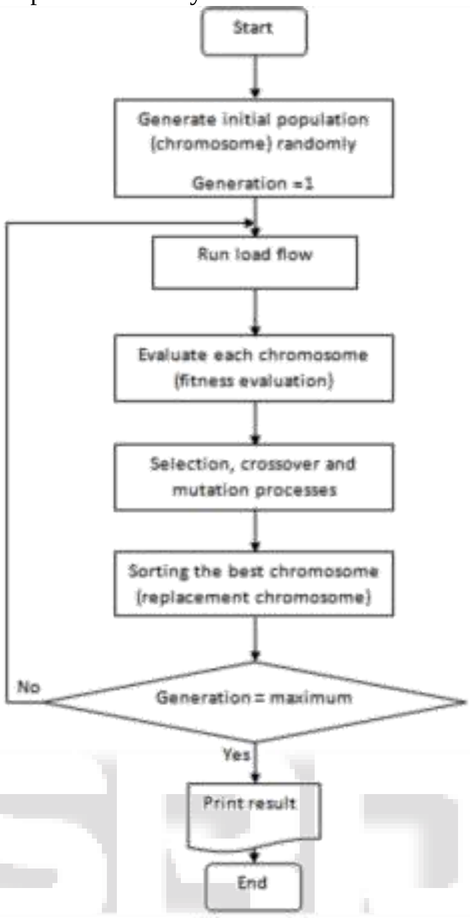

Fig. 3: Flow diagram of Genetic Algorithm

VI. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) is inspired of the behaviours of social models like bird flocking or fish schooling. It is a stochastic optimization technique first introduced by Kennedy and Eberhart for continuous nonlinear functions. PSO is based on individual improvement and social cooperation as well as competition in the population. All particles are initiated randomly and assigned a position and velocity. The particles iteratively evaluate the fitness of the candidate with finding the best value of each particle (local search) and best value of particle in the entire swarm (global search). Priya and Kalyani [11] have demonstrated on 15-bus and 69-bus distribution system and applied PSO for optimal allocation of DGs. They concluded that The average voltage before and after placement of DG is 0.9637 (p.u) and 0.9681 (p.u) for 69 bus distribution system. Without DG Placement the total power loss is 2394.83 MVA and after placement of DG total MVA loss is 1706.44 MVA. Varesi [12] has experimented on 30-bus and 33-bus distribution system and concluded that using type 2 DG units reduce system power loss about 20% more than type 1 DG units.

VII. FIREFLY ALGORITHM

The firefly optimization algorithm is inspired from the natural behaviour of the fireflies. All fireflies will move towards more attractive and brighter ones regardless their sex. The firefly with maximum brightness has the greatest ability to attract other fireflies. Attractiveness of a firefly is proportional to its brightness which ultimately decreases with the separating distance from the other firefly. The brightness of a firefly is affected or determined by the value of the objective function of a given problem. For maximization problems, the brightness is proportional to the value of the objective function whilst for a minimization problem the brightness is inversely proportional to the value of the objective function. Fig.4 shows the flow diagram of firefly algorithm. Nadhir et al. [13] have tested on IEEE 69-bus and IEEE 33-bus distribution systems with three cases, without DG and with one and two DG included in the system and concluded that incorporating the DG in the distribution system can reduce the total line power losses and improve the voltage profile. For the 69 bus system, penetration of 1 DG reduce the total real power loss by 9.07% and further reduce the real power loss by 20.97% by using 2 DG units. Mohamed et al. [14] have applied firefly algorithm on unbalanced IEEE 37-node distribution feeder and the results show the effectiveness, high speed of convergence and accuracy of the proposed method.

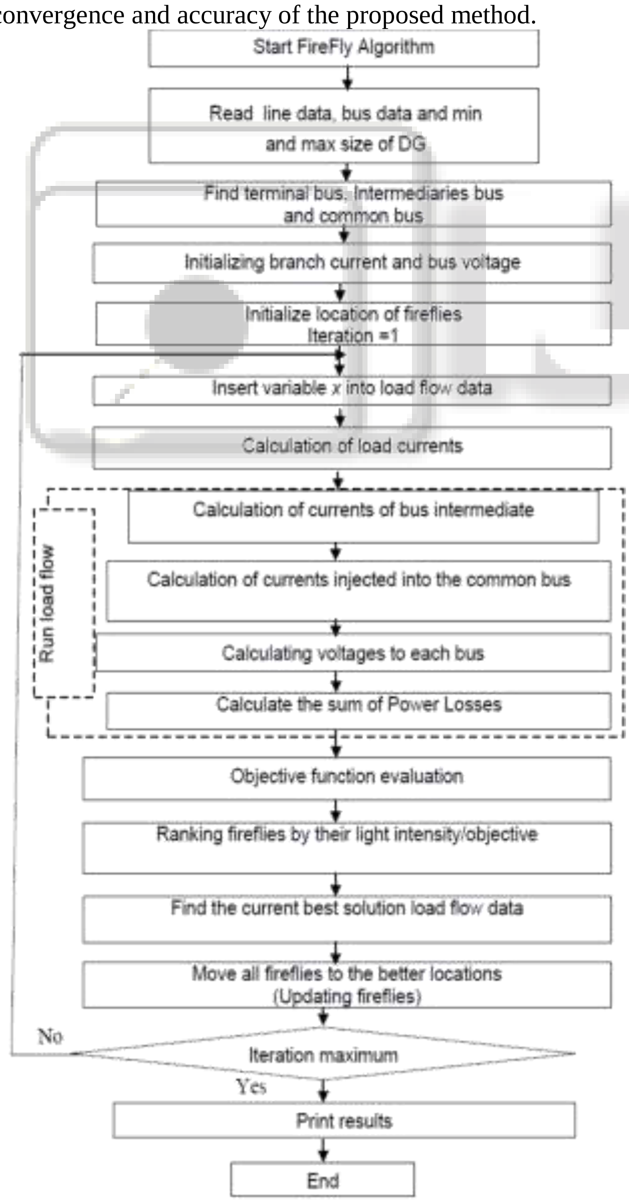

Fig. 4: Flow diagram of firefly algorithm

VIII. CUCKOO SEARCH ALGORITHM

Cuckoo search (CS) was inspired by the habit of some cuckoo species to lay their eggs in the nests of host birds of other species. Host birds get engage in direct contest with the infringing cuckoos. If a host bird discovers the alien eggs it will either throw these eggs away or simply abandon its nest and build a new nest elsewhere. Parasitic cuckoos often choose a nest where the host bird timing of egg-laying is same. Cuckoo eggs hatch slightly earlier than their host eggs. Once the first cuckoo chick is hatched it will evict the host eggs by propelling the eggs out of the nest. Cuckoo chick can also mimic the call of host chicks. These two instinct characteristics of cuckoo chick increase the cuckoo chick's share of food provided by its host bird. In nature, animals search for food in a random manner and the next move is based on the current location/state and the transition probability to the next location.

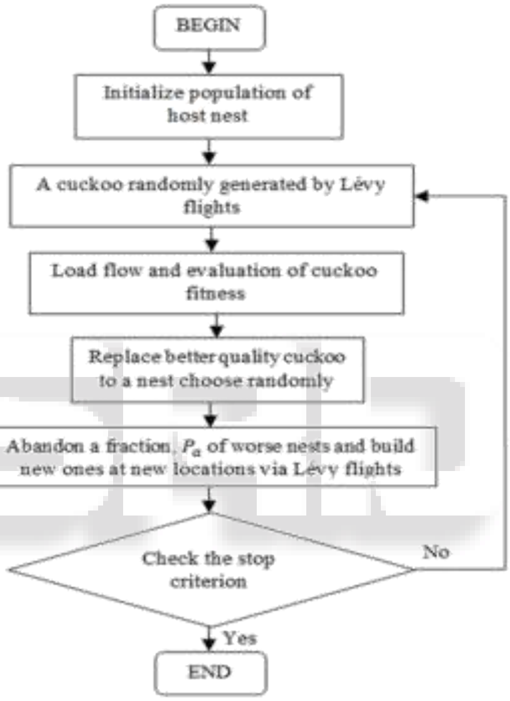

Fig. 5: Flow diagram of Cuckoo Search Algorithm

Which direction it chooses is decided by levy flight. Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest. The best nests with high quality of eggs will carry over to the next generation. The number of available host nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability of (0, 1). Discovering operates on some set of worst nests, and discovered solutions dumped from further calculations. Fig.5 shows the flow diagram of CS algorithm. Tan et al. [15] have demonstrated on 69-bus distribution system for allocation and sizing of DGs and applied GA, PSO and CS algorithm and concluded that CS algorithm provides best results with minimum power loss. CS is very precise, with standard deviation values of 0.0088; while SGA and PSO have higher standard deviation values, which are 0.2229 and 0.2103 respectively. Moravej and Akhlaghi [16] have experimented on 38-bus and 69-bus distribution system and proposed that CS algorithm is more efficient as number of parameters to be tuned is less than GA and PSO and convergence rate is not sensitive to the parameters used. Buaklee and Hongesombut [17] have applied CS Algorithm based method for optimal allocation and sizing of DG in the DIgSILENT environment to a simplify 9-bus distribution network. They concluded that the power losses reduction in case of one DG, two DGs and three DGs installation compared with no DG will be 93.11% 97.06% and 97.85% respectively.

IX. CONCLUSION

In this paper various methods of optimal allocation of Distributed Generation (DG) has been reviewed. Various population based Meta heuristic optimization techniques like Ant Colony Optimization, Artificial Bee Colony, Harmony Search Algorithm, Genetic Algorithm, Particle Swarm Optimization, Firefly Algorithm and Cuckoo Search Algorithm used for allocation and sizing of DGs are critically reviewed in this context. Study reveals that Cuckoo Search Algorithm is best method as it requires lesser parameters and gives best result by minimising power losses in distribution system.

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