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Power System Loss Minimization Using Flower Pollination Algorithm (FPA)-A Comparative Study

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Abstract: There are various methods has been attained by integrating Distributed Generation (DG) in distribution systems. These methods help to reduce power losses and improve voltage profile of the system. Desirable results can also be achieved and enhanced if optimally sized DGs will be located in the systems. This paper presents a distribution generation (DG) allocation strategy to improve node voltage and power loss of radial distribution systems using flower pollination algorithm (FPA). The main objective is to minimize active power losses while keeping the voltage profiles in the network within specified limit.

Keywords: FPA, BFO, DG, Motors.

I. INTRODUCTION

Advancement in communication and data processing technology leads to increasing demand among electric utility companies. Automation reduces the complexity of power distribution systems. By using these technology utilities could save as 10% of their annual maintenance and operating expenses. Nowadays reactive power planning (RPP) has also become a most challenging problem in power system. Reactive power control/dispatch is an important function in the planning process for the future of power systems. It aims to utilize all the reactive power sources efficiently, which are suitably located and sized in the planning process.The rapidly increasing construction costs of electrical generating stations and the fuel used therein have focused attention on the need to reduce the power and energy losses in transmission and distribution lines. Network reconfiguration in both of these cases can be classified as a minimal spanning tree problem. A method is needed to quickly find the network configuration which minimizes the total real power loss of the network. Heuristic methods have been used successfully to find sub-optimal solutions rapidly. The genetic algorithm and simulated annealing require more computation time, to find optimal solutions and only applicable small, balanced, or single-phase distribution systems. Power utility companies currently need an algorithm which can be applied to their large three-phase unbalanced distribution systems.

Accordingly, there is interest in methods that lead to energy savings and deferment of the need for construction of new facilities. Generally, throughout the developed industrialized countries, the consumers of electrical energy are guaranteed a good quality of power, which means within a certain tolerance of voltage (±5%), frequency (±0.5%) with minimum harmonics and with as possible interruption time. It is important to continue to make improvements in the distribution system to satisfy the load demand at a lower cost [1].

II. DISTRIBUTION SYSTEM LOSSES

A number of power losses in the electric distribution system and where they largely occur in the system are of a great interest to the engineers in developing a rate structure for different classes of customers. It is necessary to supply additional energy over that required to satisfy the load to compensate for the losses in the system. The locations of these

Distribution System Losses Reduction

In recent years, there has been a continuous need to accommodate higher loads and overcome delays in the construction of new generating facilities arising from environmental concerns and higher investment costs. Distribution systems have been reported over the years.

There are three basic methods to reduce system losses in the distribution system:

a) Reduce the equivalent resistance.

b) The placement of compensating capacitors.

c) Network reconfiguration.

The first method is to reduce the equivalent resistance of the system conductors. The power loss in the conductor is given by I2R. Reducing the value of R results in a proportional reduction in the power losses. Although these methods could give a large loss reduction, it is not cost effective, and it is not used unless there is a special need, as the cost of conductors and their installation are usually in excess of the cost of the energy saved.

The second method of power loss reduction in the distribution system is the placement of compensating capacitors at specific load nodes. The reactive power flow in power system produced losses. These losses can be kept to a minimum by applying compensating capacitors in distribution points, to inject reactive power, and thus compensate for the inductive load power. Using this method, the reactive power flowing in the system conductors are reduced, and consequently the losses therefrom. Additional advantages of the installation of capacitors include the boosting of voltage. This is to provide the feeder with the prescribed voltage range within the maximum and the minimum allowable values, respectively at the light and heavy load conditions and improving the power factor. The optimum size and location of the capacitor can be determined on the basis of the maximum cost savings in the energy loss and on the peak power loss reduction on the condition that the voltage limits are not violated.

The third method to reduce the power and energy losses on distribution systems is by system reconfiguration. Reconfiguration of the distribution system can be used as a planning tool as well as a real-time control tool. Most of the distribution systems are reconfigured radially and modifying the radial structure of the distribution feeders from time to time. Feeders' reconfiguration allows the transfer of loads from heavily-loaded feeders to relatively lightly-loaded feeders and from higher-resistance routes to lower- resistance routes to obtain the least I2R, where the resistance route is the total resistance from the source to the load point. Such transfers are effective not only in terms of altering the level of loads on the feeder being switched and reducing the losses but also in improving the voltage profile along the feeders and affecting reductions in the overall system power losses. Studies and experiments on feeder reconfiguration are ongoing in several utilities.

III. LITERATURE REVIEW

Abdullah M. Shaheen et al [1]: Reactive power planning (RPP) is, for the most part, characterized as an ideal portion of additional reactive power sources that ought to be installed in the system for a redefined horizon of planning at least cost while satisfying equality and inequality constraints. The optimal placements of new VAR sources can be selected according to certain indices related to the objectives to be studied. In this paper, various solution methods for solving the RPP problem are extensively reviewed which are generally categorized into analytical approaches, arithmetic programming approaches, and meta-heuristic optimization techniques. The research focuses on the disparate applications of meta-heuristic algorithms for solving the RPP problem. They are subcategorized into evolution based, and swarm intelligence. Also, a study is performed via the multi-objective formulations of reactive power planning and operations to clarify their merits and demerits.

Thuan Thanh Nguyen et al[2]: This paper proposes a reconfiguration technique in based on a cuckoo search algorithm (CSA) for limiting dynamic power loss and the maximizing voltage magnitude. The CSA strategy is another meta-heuristic algorithm motivated from obligate brood parasitism of some cuckoo species which lay their eggs in the homes of other host winged animals of different species for taking care of enhancement issues. Contrasted with different techniques, CSA strategy has fewer control parameters and is more successful in enhancement issues. The viability of the proposed CSA has been tried on three diverse dissemination organize frameworks and the acquired test outcomes have been contrasted with those from different techniques in the writing. The recreation comes about demonstrate that the proposed CSA can be a proficient and promising technique for distribution network reconfiguration problems.

Vladimiro Miranda and Nuno Fonseca [3]: This paper shows another meta-heuristic (EPSO) manufactured assembling the best elements of Evolution Strategies (ES) and Particle Swarm Optimization (PSO). Cases of the superiority of EPSO over traditional PSO are reported. The paper also describes the use of EPSO to real world problems, incorporating an application in Opto-gadgets and another in Power Systems.

Satish Kumar Injeti et al[4]: In this paper, two new calculations are executed to optimal placement of capacitors in radial distribution systems in two ways that is, ideal arrangement of fixed size of capacitor banks (Variable Locations Fixed Capacitor banks-VLFQ) and ideal measuring and position of capacitors (Variable Locations Variable estimating of Capacitors-VLVQ) for real power loss minimization and network savings maximization. The two bio-inspired algorithms Bat Algorithm (BA) and Cuckoo Search (CS): look for every single possible area in the system alongside the different sizes of capacitors, in which the ideal sizes of the capacitor are been standard sizes that are accessible in the market.

To check the achievability, the proposed calculations are connected on standard 34 and 85 85 bus radial distribution systems. Also, the result is compared with different techniques like Particle Swarm Optimization (PSO), Harmonic Search (HS), Genetic Algorithm (GA), Artificial Bee Colony (ABC), Teaching Learning Based Optimization (TLBO) and Plant Growth Simulation Algorithm (PGSA), as available in the literature.

Nitin Garva and Abhishek Sanghi [5]: Distributed generation has been envisaged to play an escalating role in the electrical power system in near future. However, the benefits of dg cannot be explored if they are not optimally placed. This paper presents a state of the art on optimal placement of different types of DGs. loss. One of the proven Meta-Heuristic techniques PSO has been used to solve the optimal location of DGs. The proposed technique is tested on 33 buses 38 bus and 69 bus test systems.

M.E. Hamedani Golshan and S.A. Arefifar [6]: The strategy has been tried on 33-bus and 69-bus radial distribution systems to show the execution of the calculation and to explore effect of a few parameters, for example, most extreme cutoff points on size of DGRs (RPSs), consistent or controllable outputs of these sources and different control factors sets on results of system planning. Moreover, a novel method for deciding the candidate buses to install active (reactive) sources based on clustering system buses in perspective of assigning DGRs (RPSs) is presented.

O. Abarrategui et al [7]: This paper shows another met heuristic technique, for Feeder Reconfiguration in dispersion systems, called Item Oriented Ant Colony Optimization (IOACO), with four varieties in view of various Ant Colony Optimization calculation approaches (ACO). The procedure changes and adjusts beforehand proposed ACO strategies so as to enhance their productivity and accuracy in solving the problem of loss reduction in a distribution network.

Susana de Leon-Aldaco et al [8]: This paper introduces a complete scope of met heuristic procedures connected in the range of power converters. The review includes a classification of the methodologies and main objective functions in each paper reviewed. An aim of this paper is to highlight the significance of the optimization tools, and the many advantages they give to handle the difficulties experienced in the design, operation, and control of power converters.

R. Srinivasa Rao et al[9]: This paper presents another technique which applies an artificial bee colony algorithm (ABC) for deciding the sectionalizing switch to be worked with a specific end goal to understand distribution system loss minimization problem. The ABC algorithm is another populace based meta-heuristic approach inspired by intelligent foraging behavior of honeybee swarm. The proposed technique has outperformed alternate method regarding the nature of arrangement and computational proficiency

Merlin and Back [10] proposed a branch and bound type heuristic method to decide the system setup for minimum line losses. In this process, the switch to be opened at each stage is selected in order to minimize line losses of the resulting network. The essential points of interest of this strategy are: the final network configuration is independent of the initial stage of the network switches. The solution process leads to the ideal or close ideal. The major drawbacks are: Loads are expected simply dynamic and are represented by current sources that are fixed regardless of the changing network configuration. Organize Network voltage angles are assumed negligible.

Shirmomohammadi and Hong [11] improved the strategy for Merlin and Back. Accordingly, it shares the two guideline advantages of that methodology, meeting to the optimum or near optimum solution and the independent of the final solution from the initial status of the system switches. In the meantime, this technique maintains a strategic distance from all the significant disadvantages of Merlin and Back.

Civanlar [12] built up a branch trade strategy. In this technique, loss reduction is accomplished by exchange operation compares to the determination of a couple of switches, one for opening and the other for shutting so that the subsequent system has lower line losses while remaining connected and radial. The major drawbacks of this technique are: The final system reconfiguration is subject to the initial state of the network switches. The optimum solution is not ensured. Choice of each switches exchange operation becomes very time-consuming.

Baran and Wu [13] presented a heuristic reconfiguration technique in view of the branch exchange to reduce losses and adjust the loads in the feeders. Two approximated load flows for radial networks with different degrees of accuracy are used. They are basic Dist flow technique and back and forward update of Dist stream strategy. The method is exceptionally tedious because of the complicated combinations in large scale system and converges to a local optimum solution, that is, convergence to the global optimum is not guaranteed.

V.N. Gohokar et al[14] detailed the reconfiguration issue as trans-shipment with quadratic costs utilizing the quadratic simple technique. The system begins with simply the distribution substations and the feeder portions are switched in each one in turn of the segment available to switch in, the one with minimum unit trans-shipment cost is chosen first. The linearized trans-shipment cost was characterized as the section limit times resistance, so it doesn't rely on upon load. At that point, of the other portion available to serve that new load point, the chosen segment is checked to ensure it brings about least increment in losses. This search does not necessary guarantee global optima.

S.K Goswami et al [15] characterized another arrangement of heuristic rules for distribution system reconfiguration problem. The rules have been created with the objective of reducing losses directly and make an effort quantize the suitability of switching options. The proposed technique serve as a pre-processor to a reconfiguration calculation expelling undesirable switching options without the need to perform a complex load flow analysis.

IV. FLOWER POLLINATION OPTIMIZATION ALGORITHM (FPOA)

Flower pollination optimization algorithm (FPOA) is recently invented optimization algorithm. It is acquired from the common motivation of pollination process. It mirrors the way toward flowering plants reproduction via pollination. Transferring pollens among flowers, pollination may occur in either local or global flow [4]. Pollination process can fall into two shapes classifies; biotic and abiotic based on the pollens transferring mechanism. For biotic pollinations, flowers always depend on insects and/or animals as pollinators to transfer the flowering pollens However for abiotic, flowers needn't bother with any pollinators for the pollens transferring process. Naturally, most of the flowers considered to follow the biotic pollination form. This indicates that pollination or cross pollination process can take place by pollinators' movements or travel long distances causing a global pollination. Traveling pollinators are usually followed the L'evy's flight behavior. Their flying steps also follow the Levy's flight distribution [7]. For each kind of pollinators, there is a specific type of flowers that it is responsible for, this called flower consistency. Flower consistency helps to minimize the cost of investigation of each pollinator. Evolutionary wise, it increases the transferring time of pollens and hence optimizes and maximize the reproduction process. With the limited available memory of pollinators, flower consistency eliminates the learning, investigation, and switching [8]. Furthermore, it can be considered as an incremental step based on the similarity/difference between any two flowers. The biological objective of flower pollination is to optimally reproduce new enormous generations of the flower kind with the fittest features that ensure the kind`s survival. In order to ideally formalize the flower pollination algorithm, characteristics of pollination process, flower constancy, and pollinator behavior should be approximated based on the following essential rules:

i. Global pollination achieved by L'evy's flights` traveling pollinators for both biotic and cross-pollination.

ii. Local pollination achieved abiotic and self-pollination.

iii. The new generation reproduction probability depends on the flower consistency and proportional to flowers` similarities/differences.

iv. The switching probability $p \in [0, 1]$ controls the shift between local and global pollination.

The simple flower pollination model assumes that each plant has only one flower, and each flower only produces one pollen gamete. Thus, there is no need to distinguish a pollen gamete, a flower, a plant or solution to a problem [9].

V. PROPOSED METHODOLOGY AND RESULT

Step 1: Read the distribution networks line data and bus data.

Step2: Calculate the each node current or node current injection matrix.

Step 3: Evaluate the branch current by using BIBC matrix and current injection matrix (ECI).

Step 4: Calculate the DLF matrix.

Step5: Apply FPA optimization and calculate of power in different iterations

Table 1

Iteraion	0	5	10	20	25
Powerloss(proposed)	190	130	124	119	109
Powerloss(BFO)	190	124	185	135	135

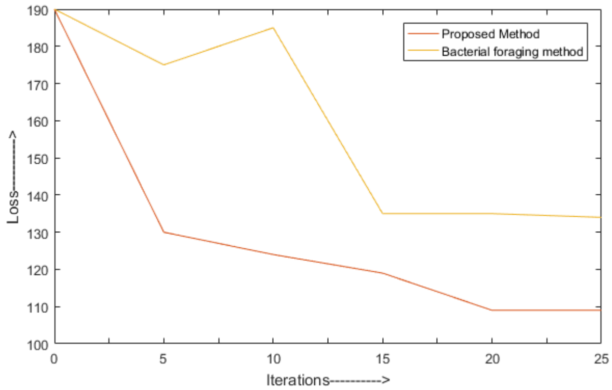

Fig 1: Comparison between Proposed method and Bacterial Foraging method

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